ROOF PONDS

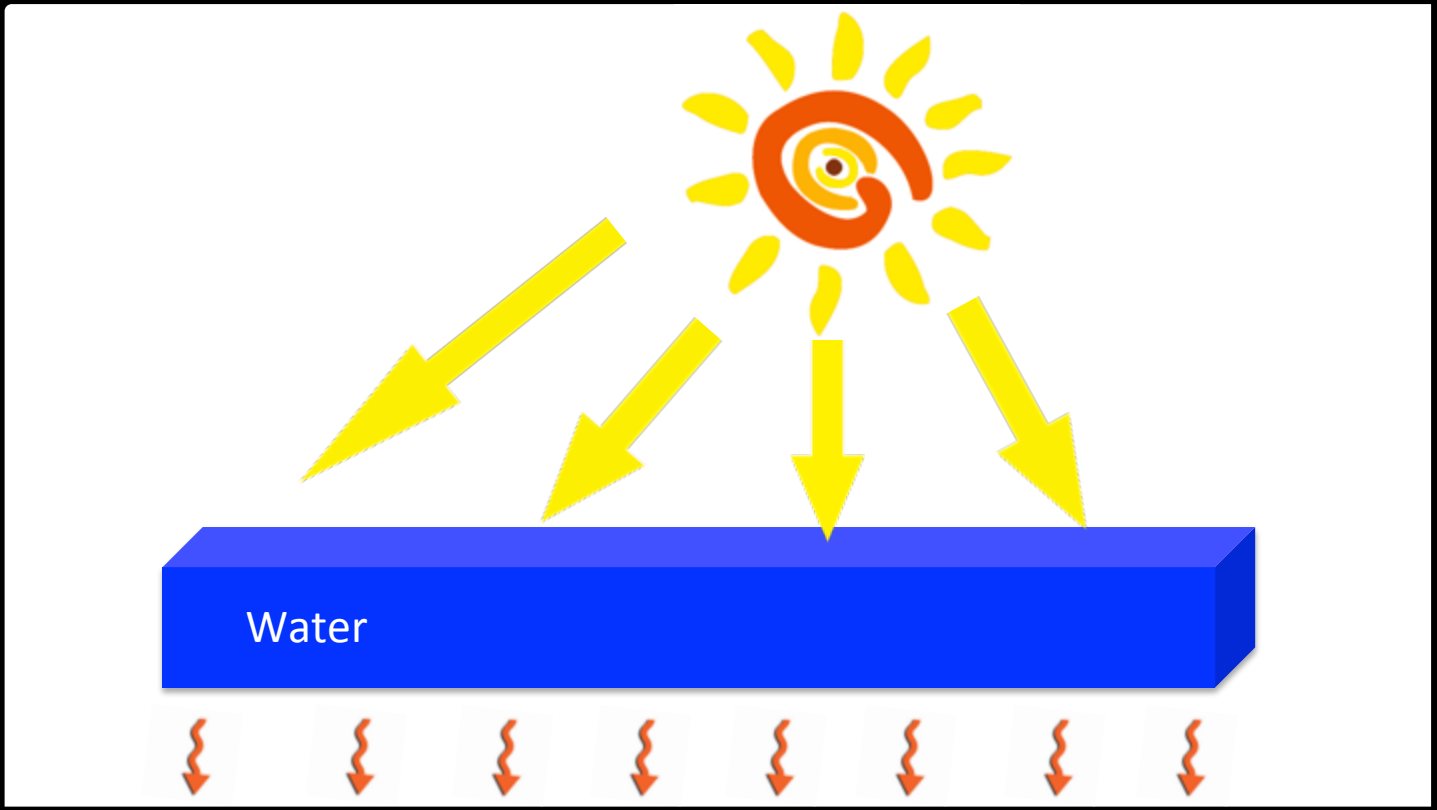
A Heating and Cooling Application through Thermal Mass Storage

An indirect gain
heating and cooling system
where the thermal mass,
which is water in plastic bags,
is located on the roof of the
space which is being heated
and/or cooled.

Indirect Gain Method from Solar Radiation

Water as Thermal mass

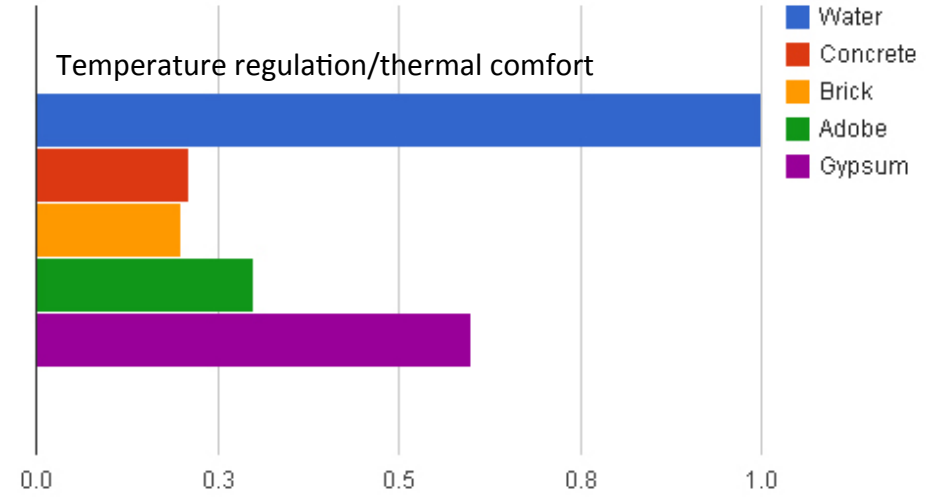
1. Absorbs
2. Transfers



Why Water ?

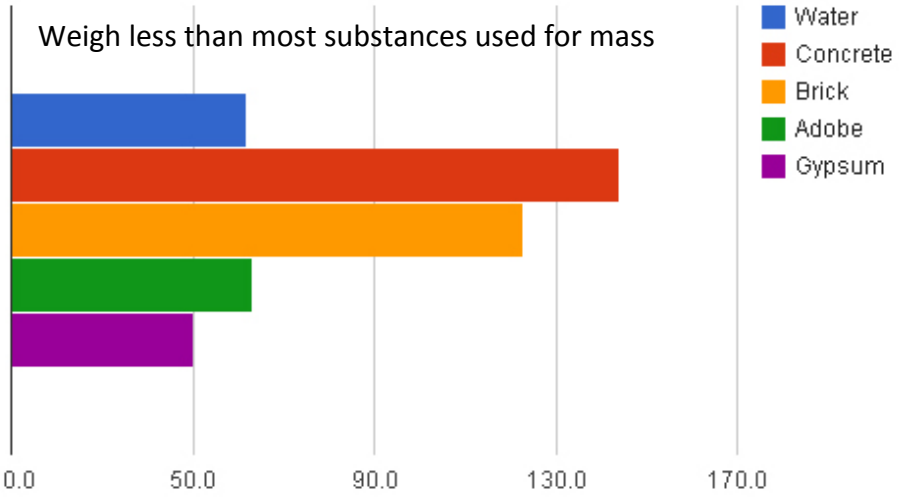
SPECIFIC HEAT
(Btu/lb•°F)

Temperature regulation/thermal comfort



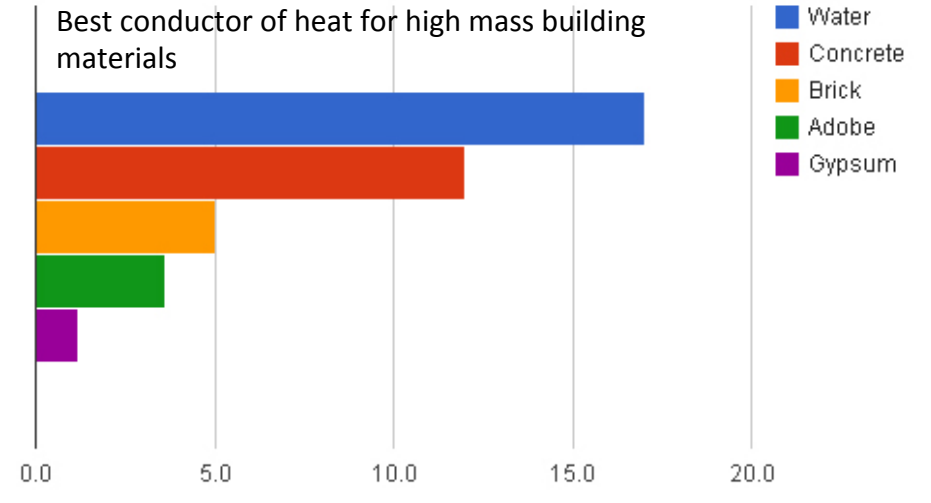
DENSITY
(lb/ft3)

Weigh less than most substances used for mass



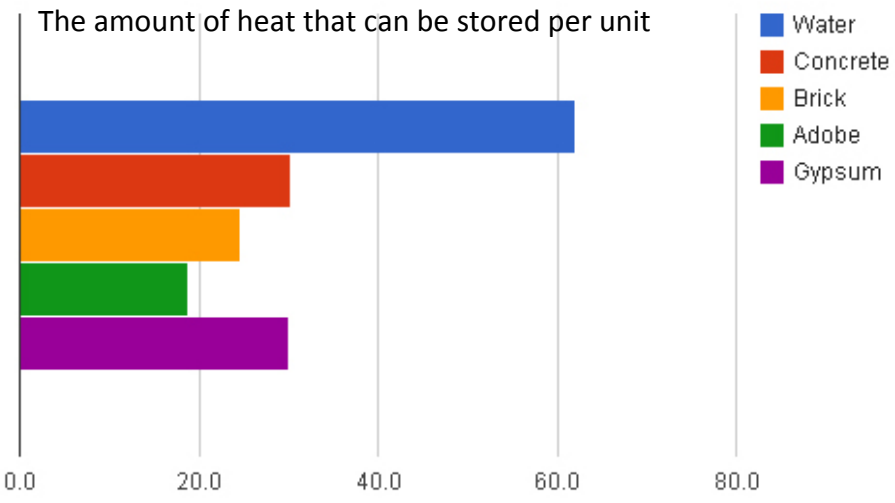
CONDUCTIVITY
(Btu•in.)/(ft2•hr•°F)

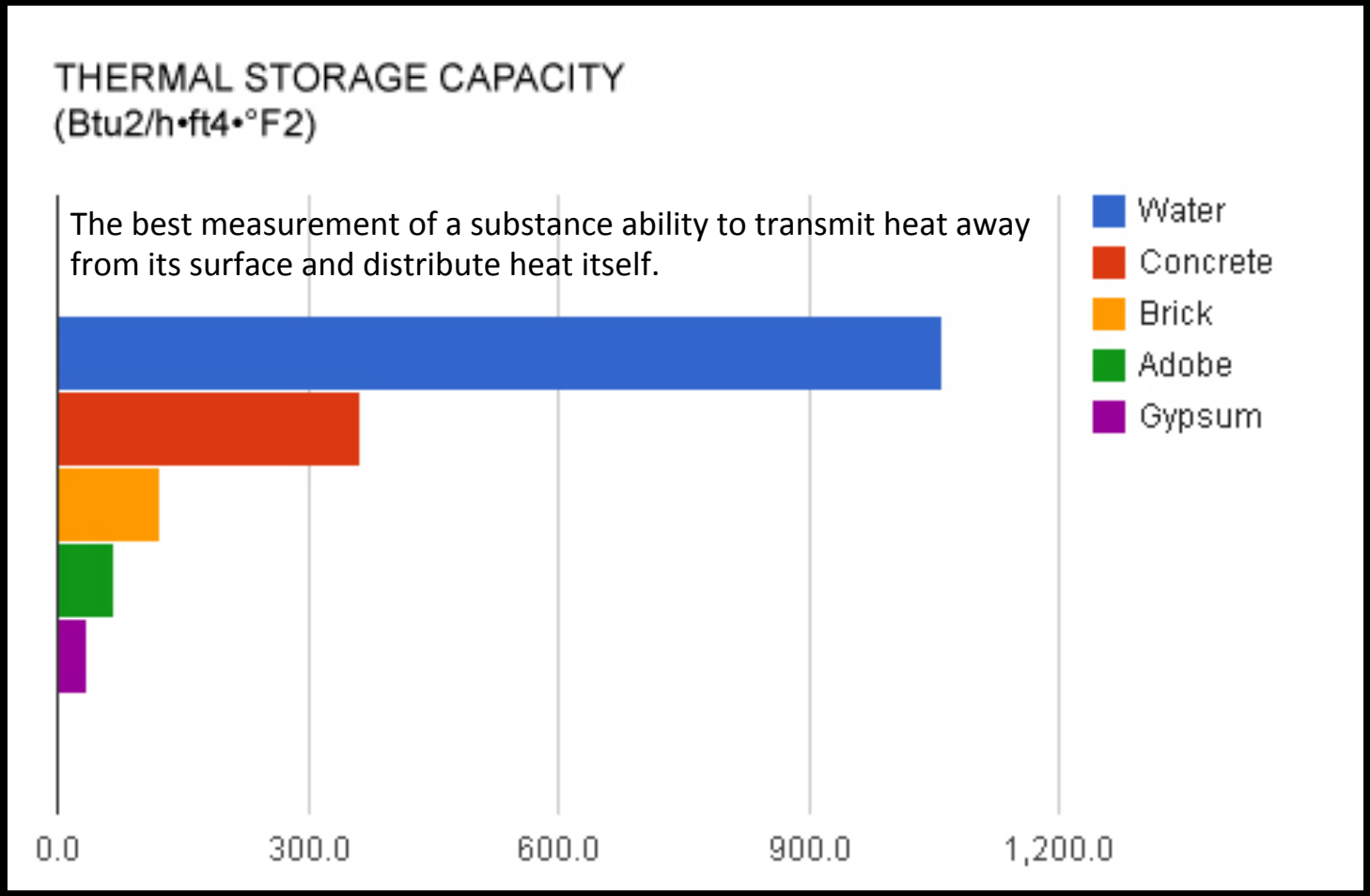
Best conductor of heat for high mass building materials



HEAT CAPACITY
[Btu/(ft3•°F)]

The amount of heat that can be stored per unit




THERMAL STORAGE CAPACITY
(Btu2/h•ft4•°F2)
The best measurement of a substance ability to transmit heat away from its surface and distribute heat itself.
Water
Concrete
Brick
Adobe
Gypsum
0.0
300.0
600.0
900.0
1,200.0

The roofpond system: defined as a *passive solar radiation system*.

Since it usually consists of motorized retractable insulation panels it is best defined as a *hybrid system*.

(It can be interactive: manual when home and motorized when gone)

Harold R. Hay, inventor of the roofpond system, originally patented the roofpond as the Skytherm™ system.

MOTHER EARTH NEWS
THE ORIGINAL GUIDE TO LIVING WISELY

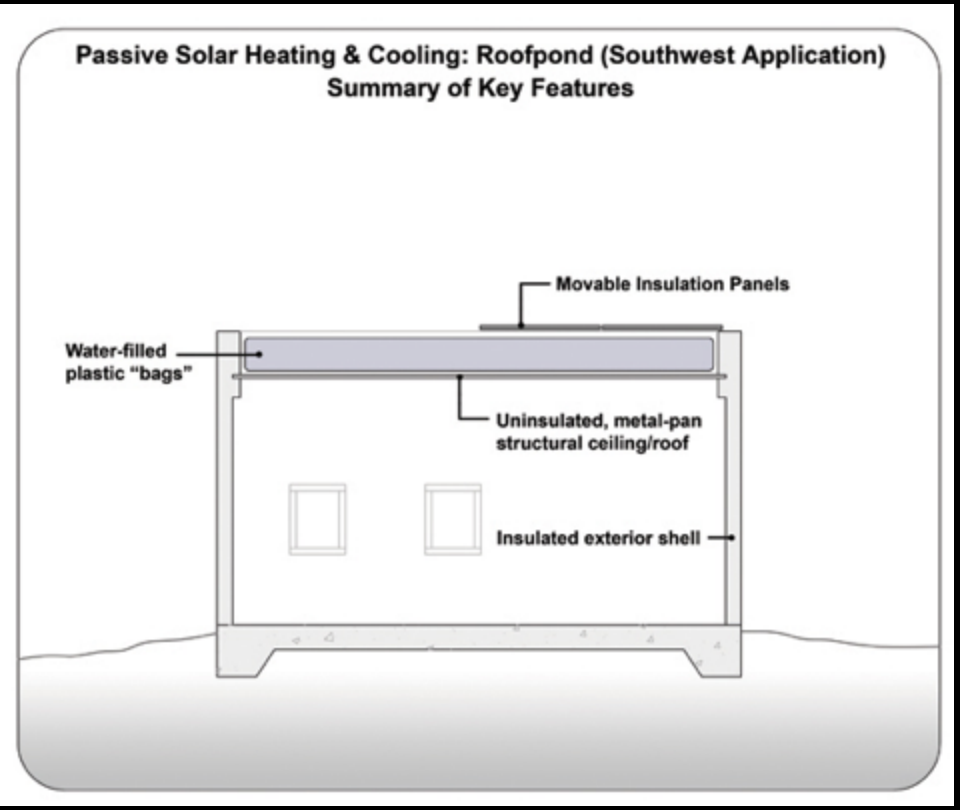
Plowboy Interview: Harold R. Hay Talks About Solar Energy

Hay shares his thoughts on solar energy, passive cooling, movable insulation and much more in this Plowboy Interview.

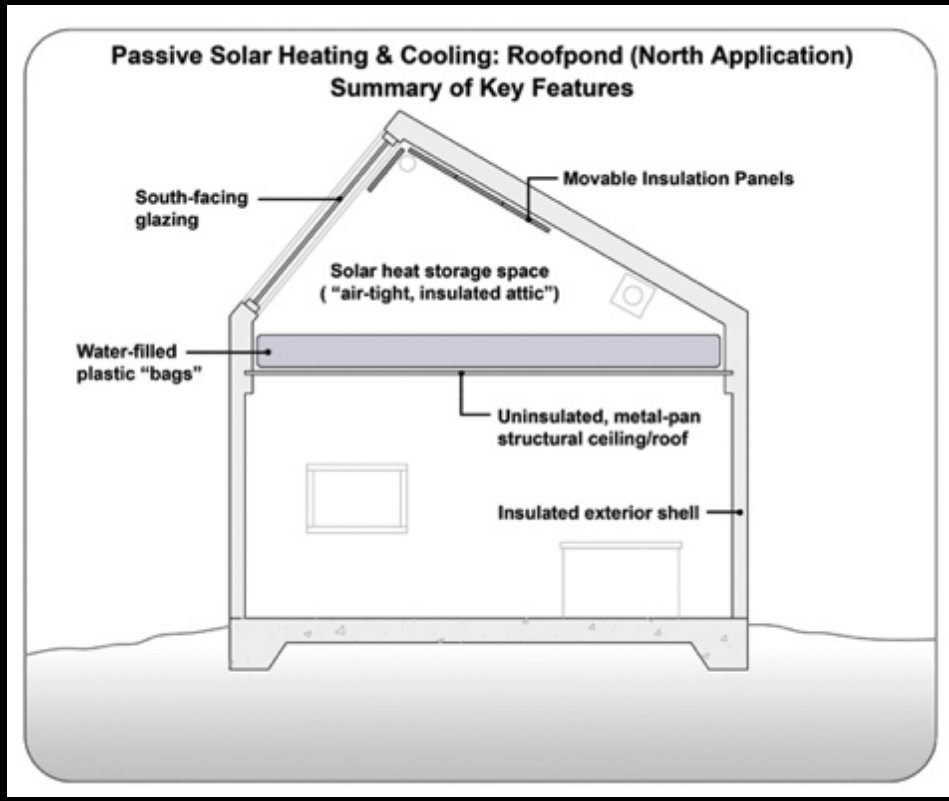
By the Mother Earth News editors
September/October 1976

There are two distinct roofpond systems:

Southwest

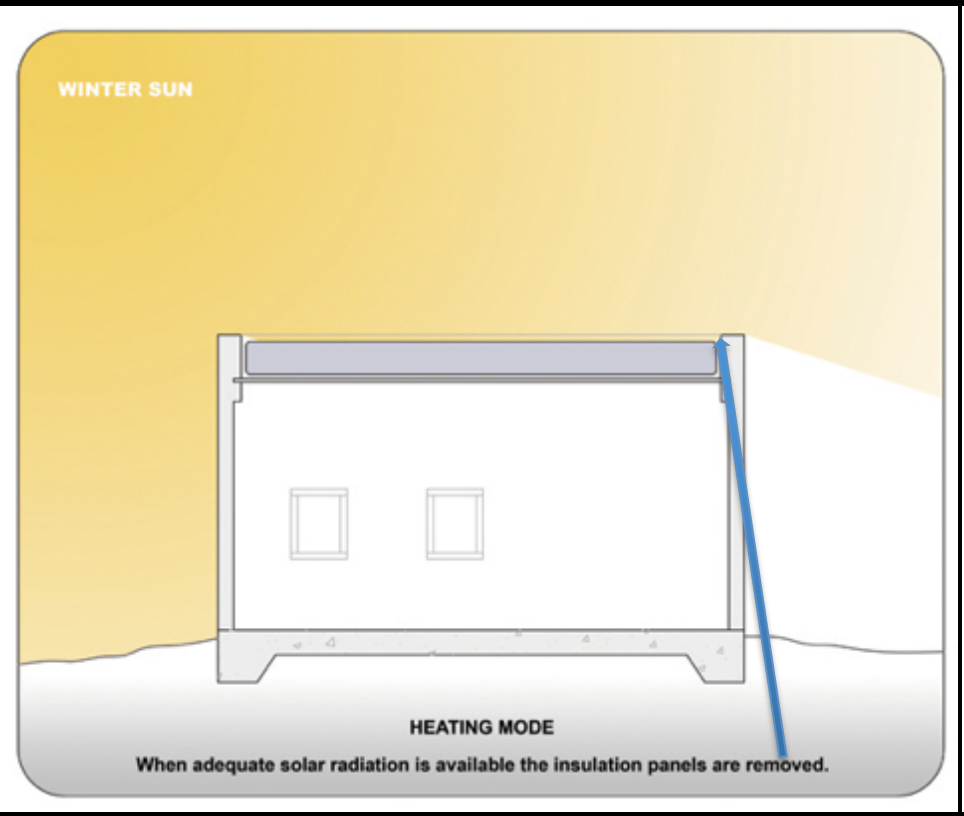


North



Roofpond systems: Heating Mode

Southwest



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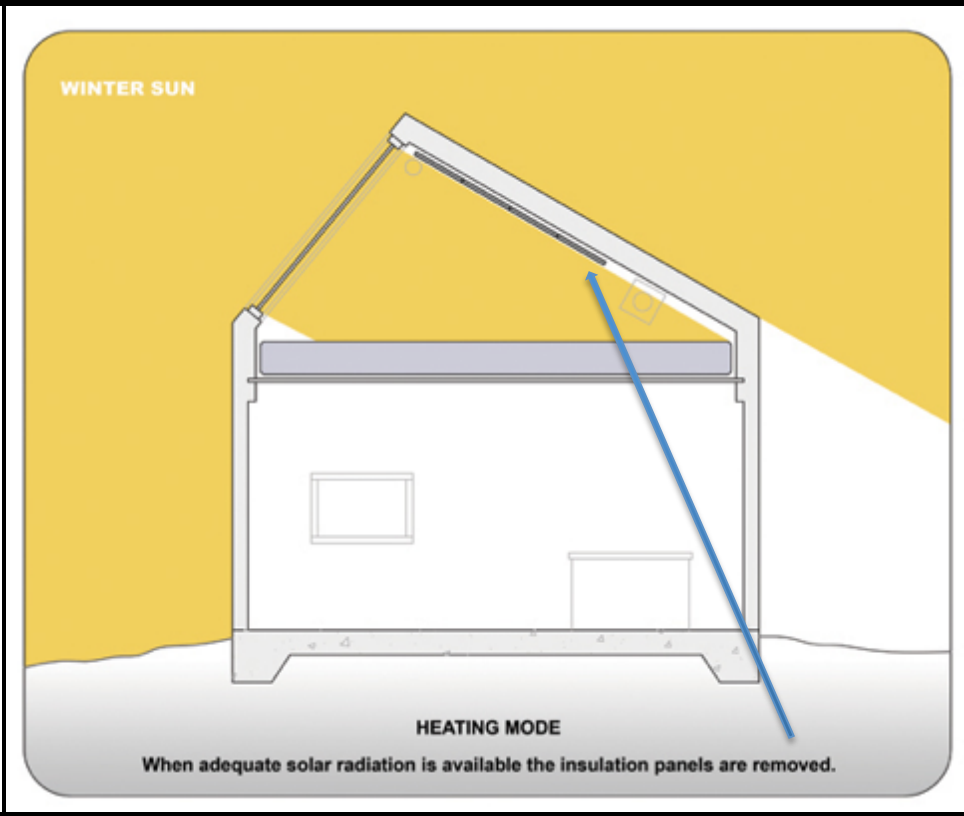

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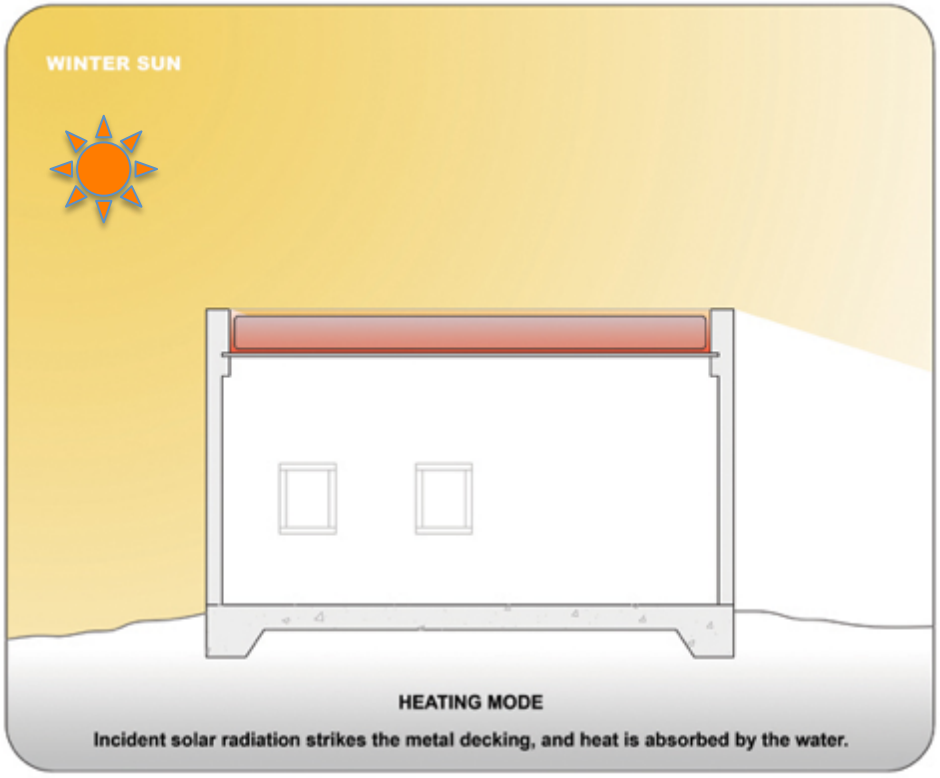

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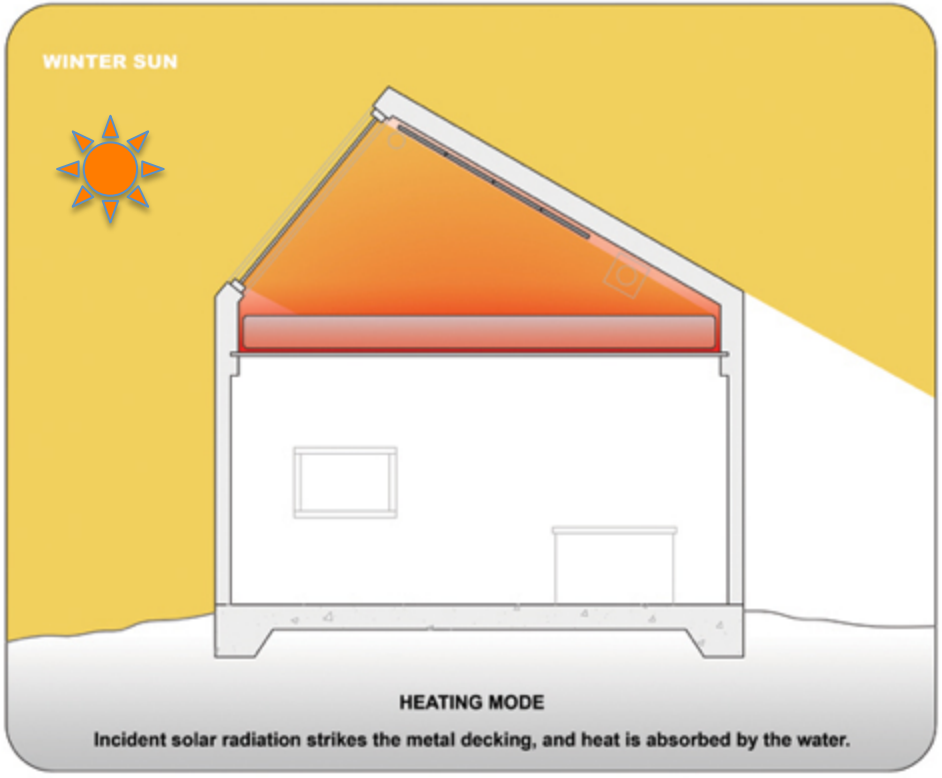

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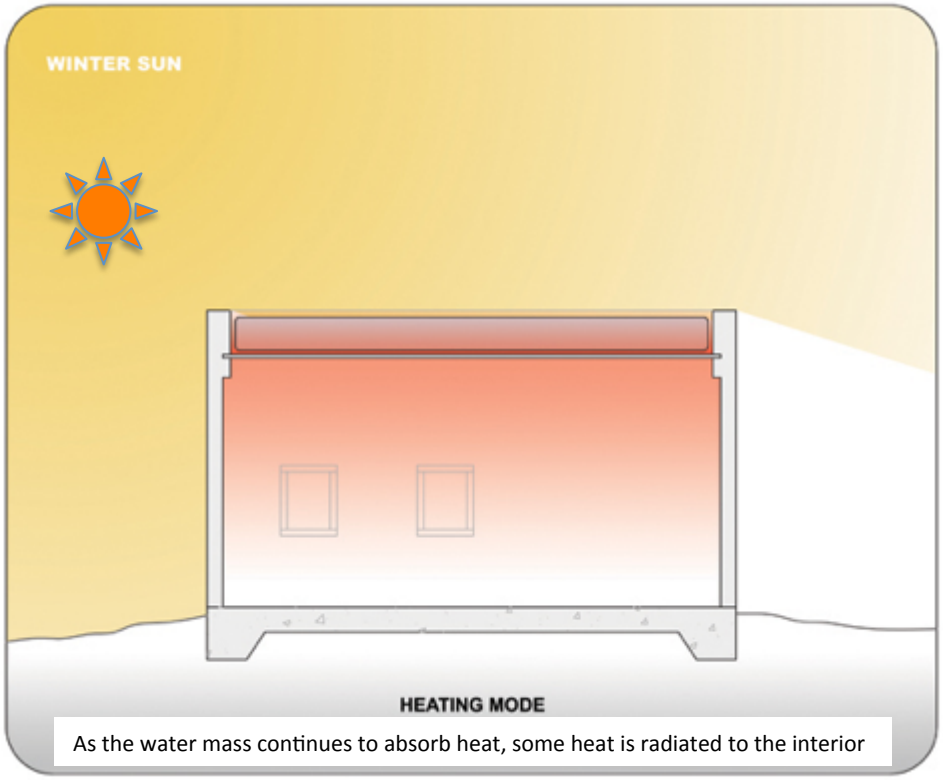
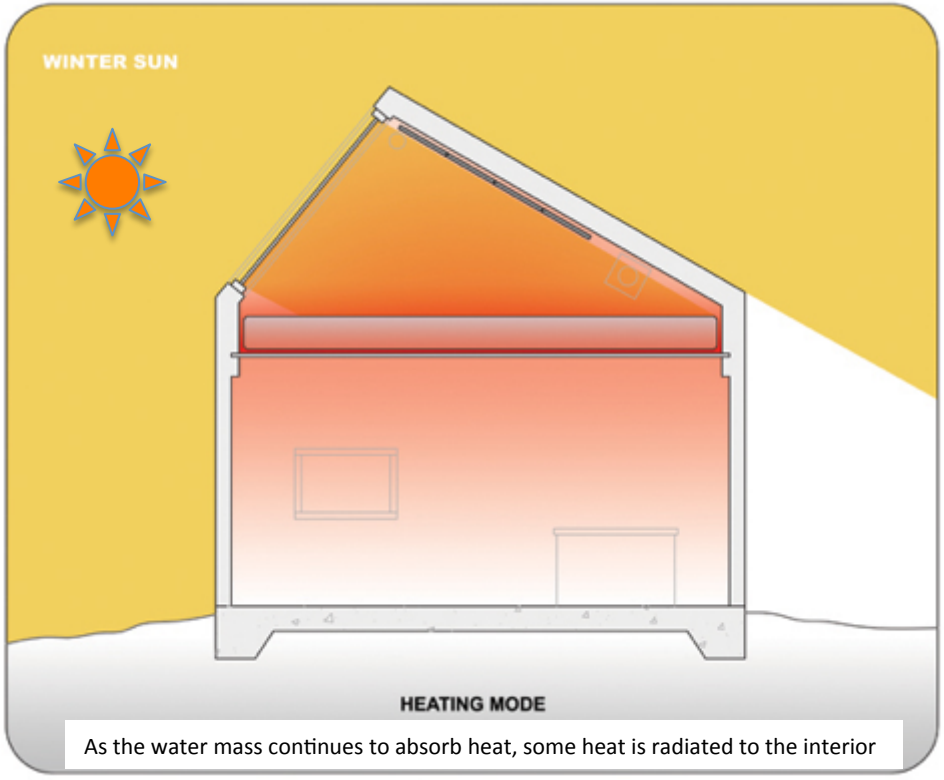


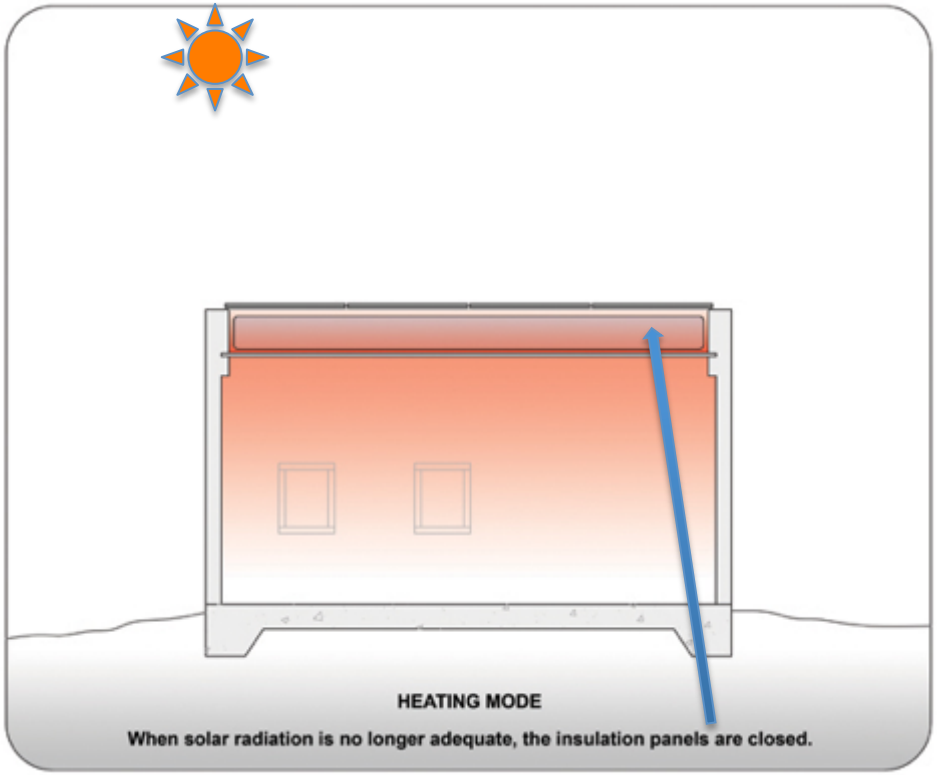
As the water mass continues to absorb heat, some heat is radiated to the interior

North



As the water mass continues to absorb heat, some heat is radiated to the interior

Southwest



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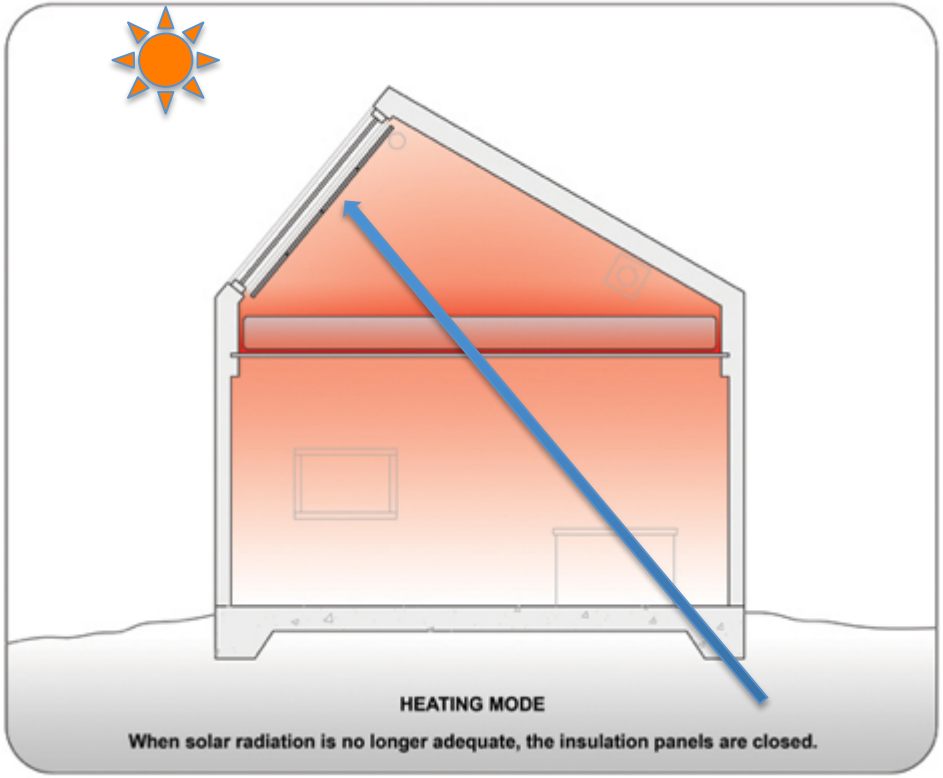

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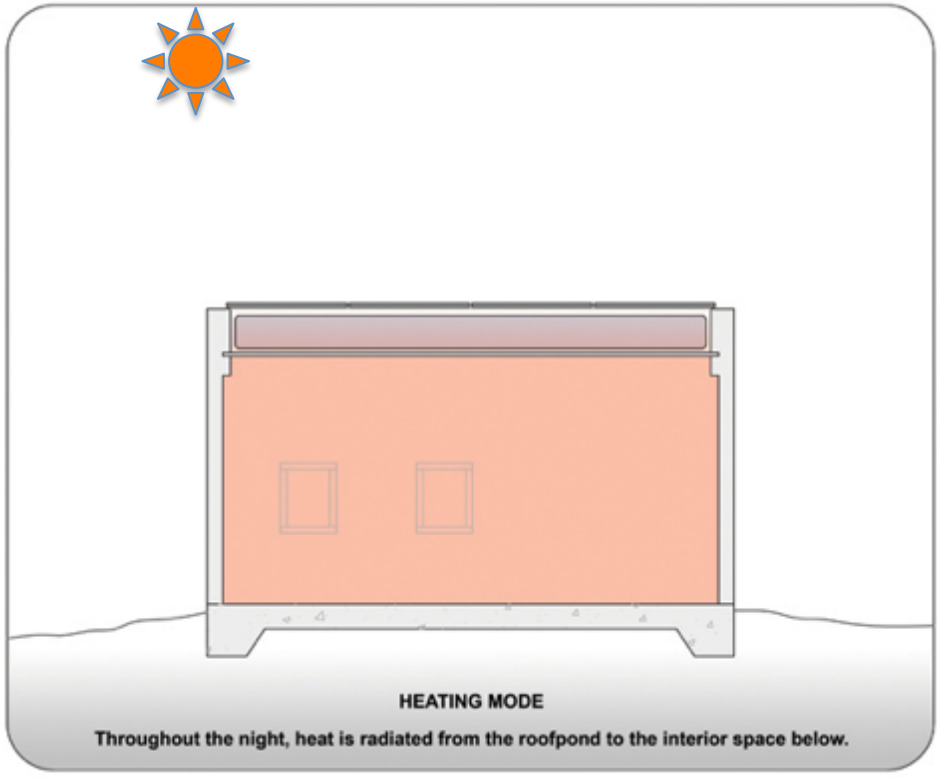

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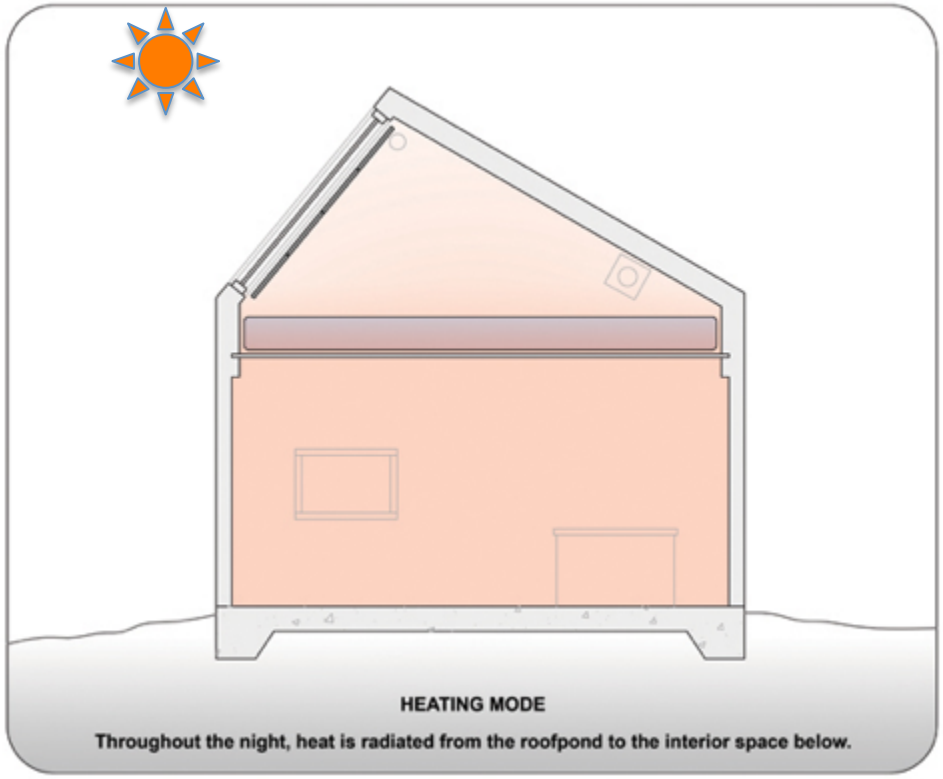
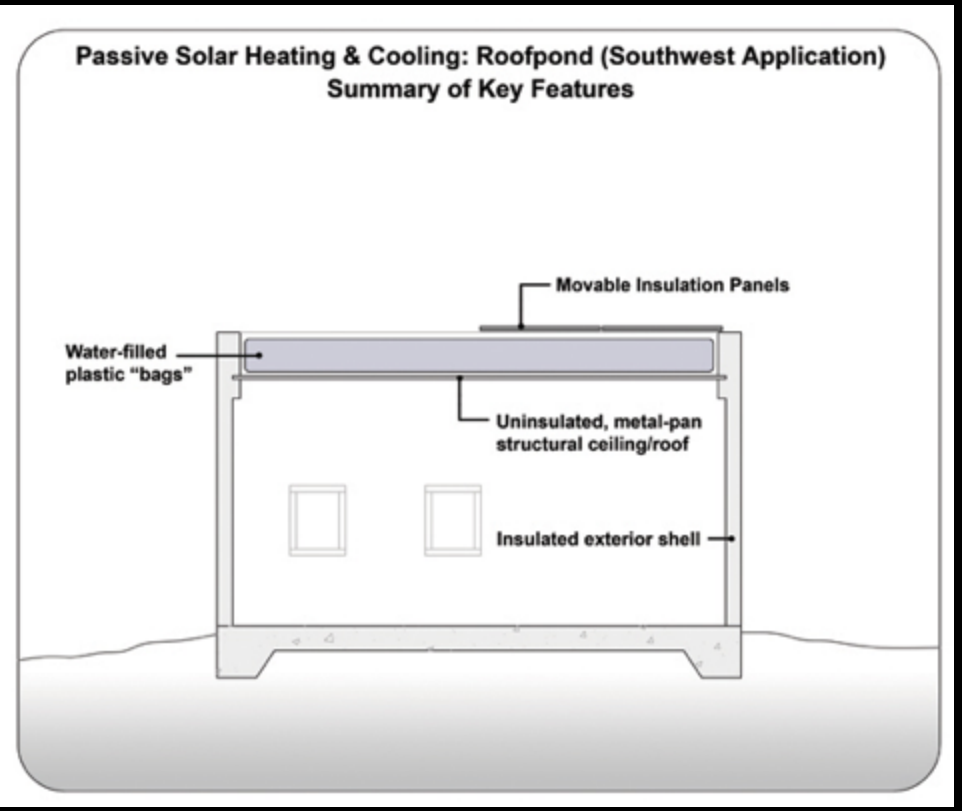


Roofpond systems: Cooling Mode

Southwest



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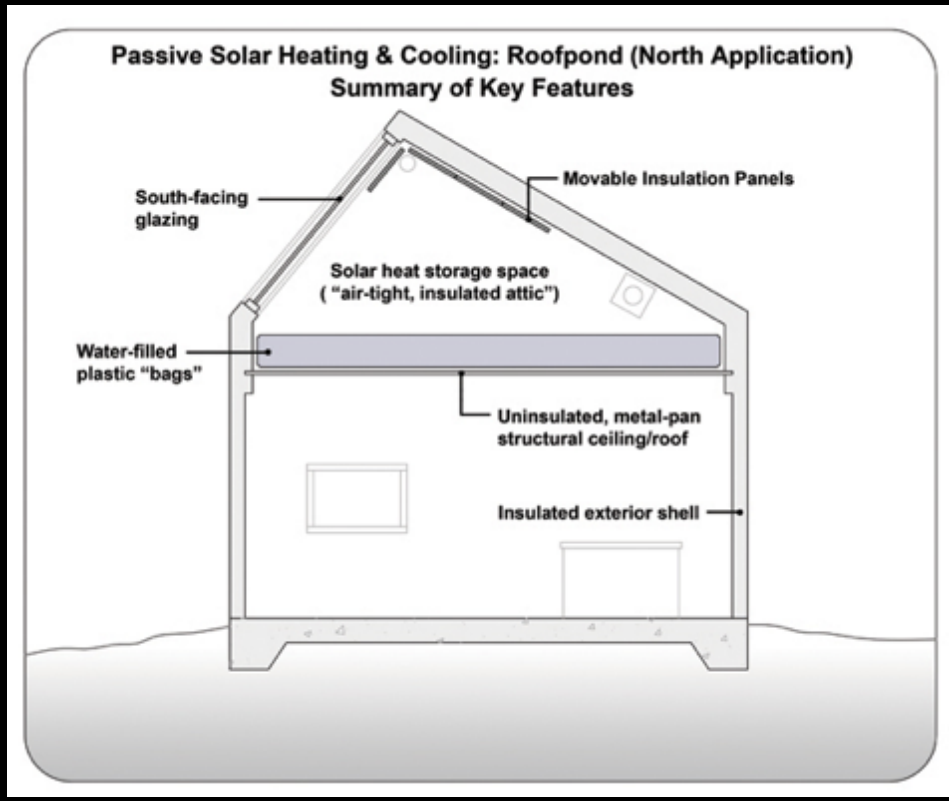

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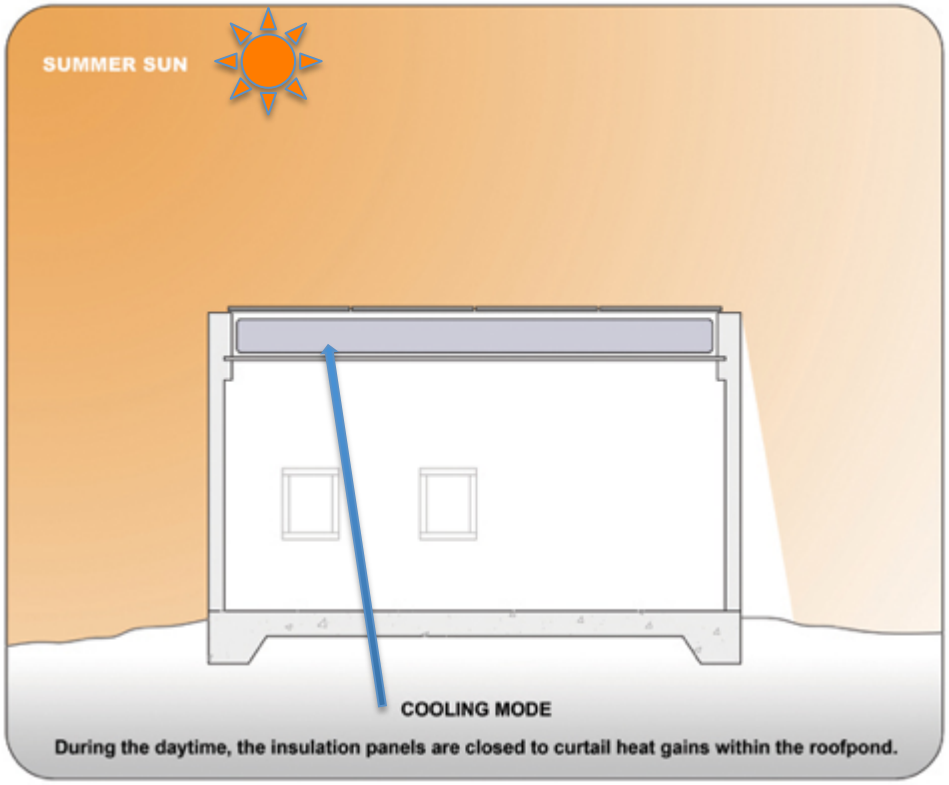

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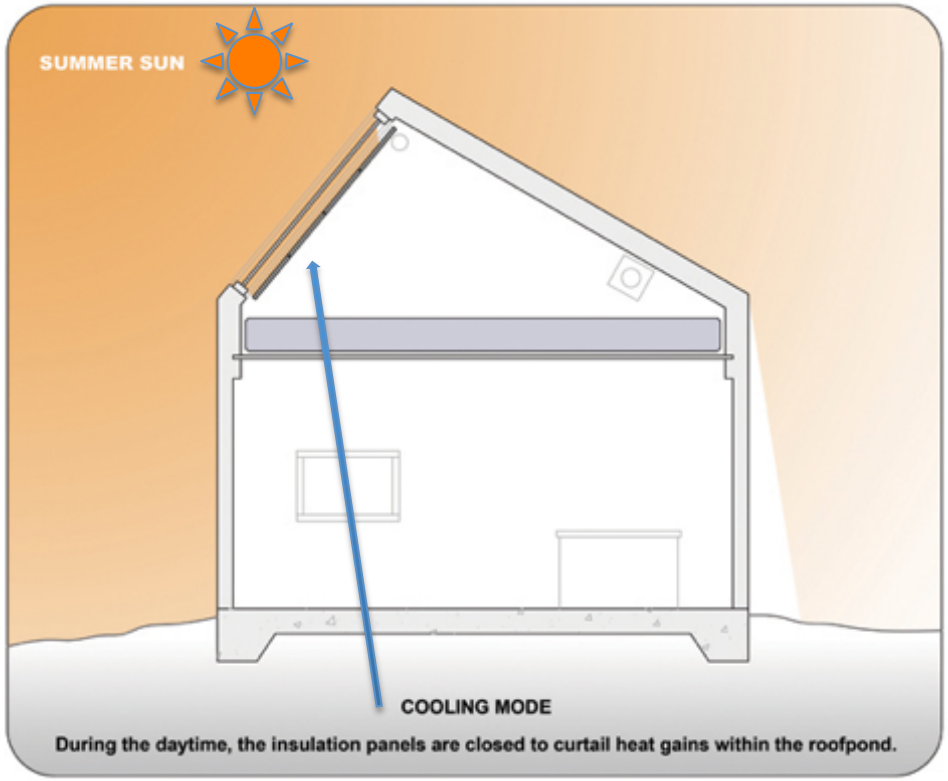

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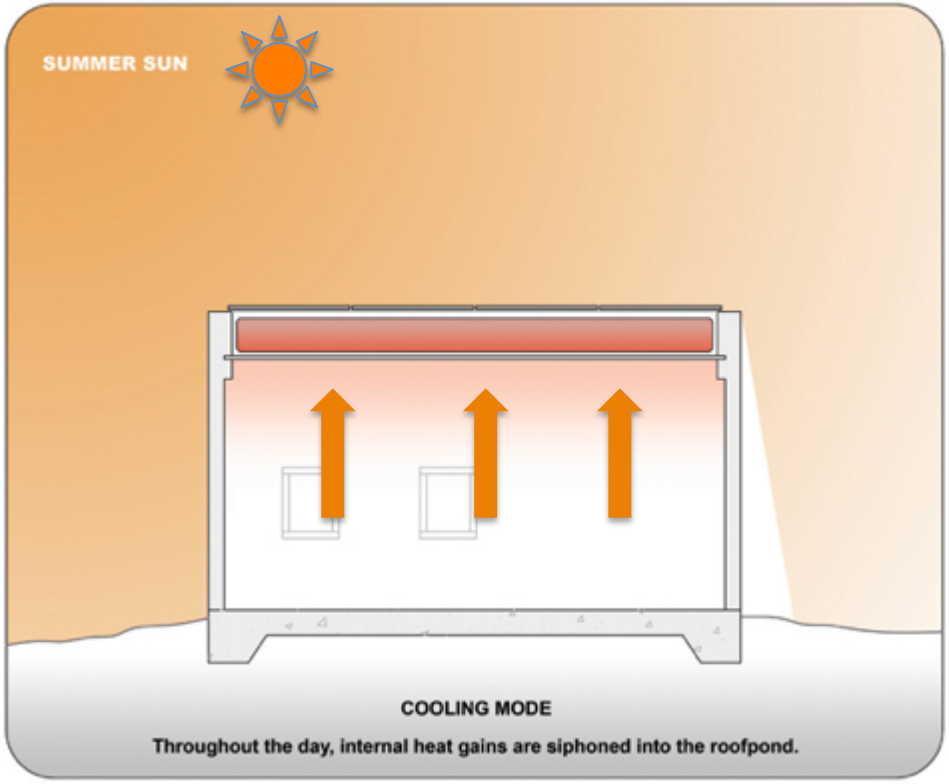

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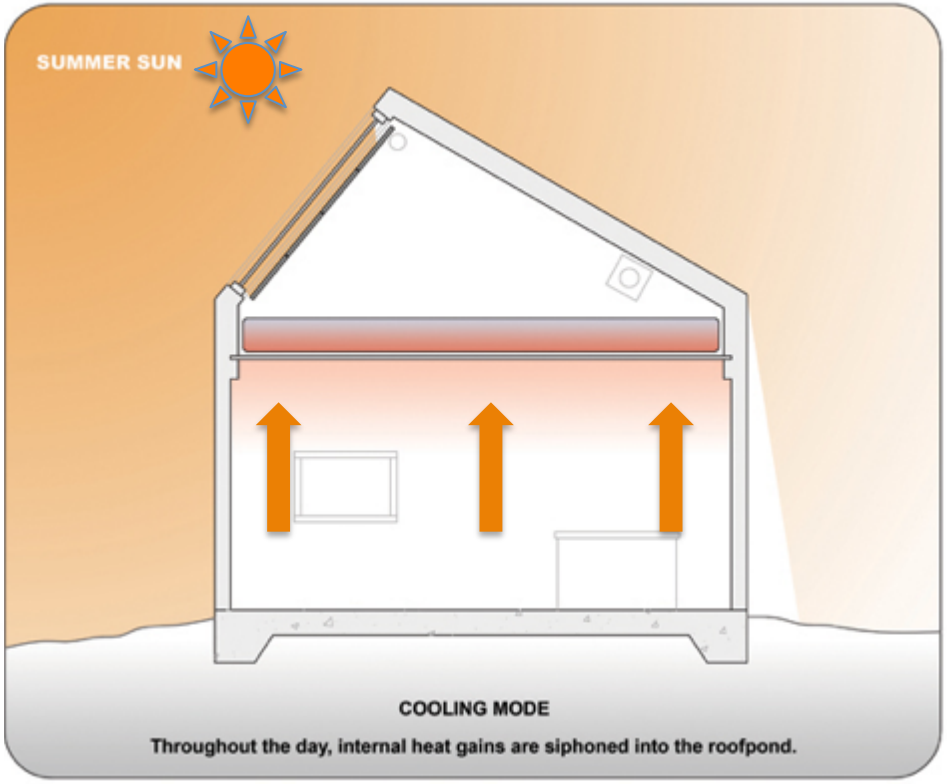

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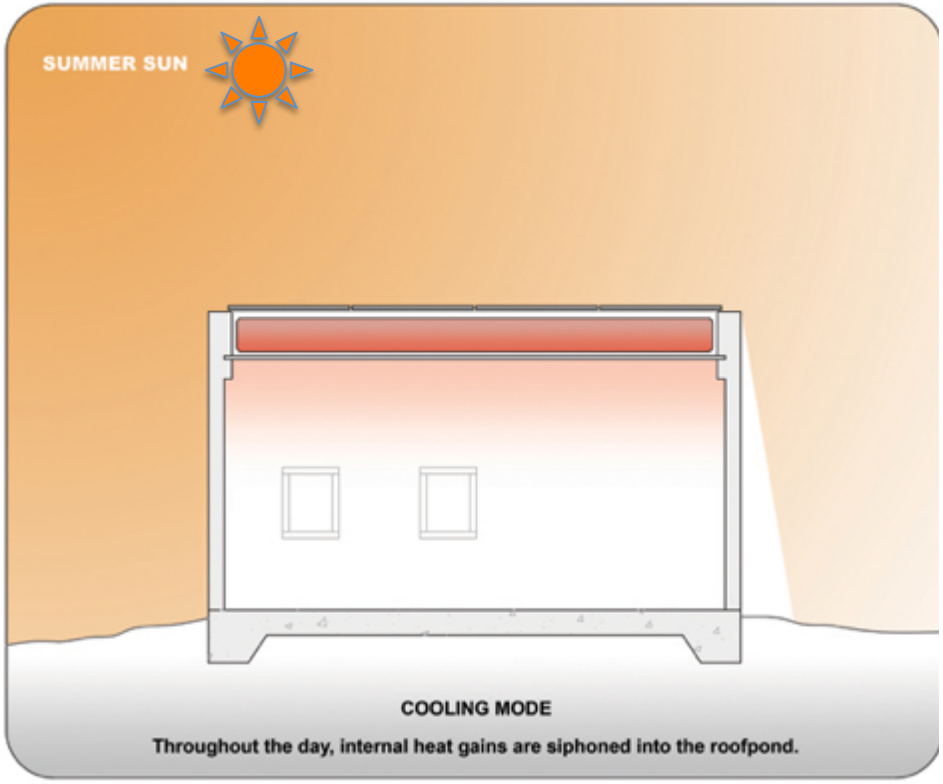

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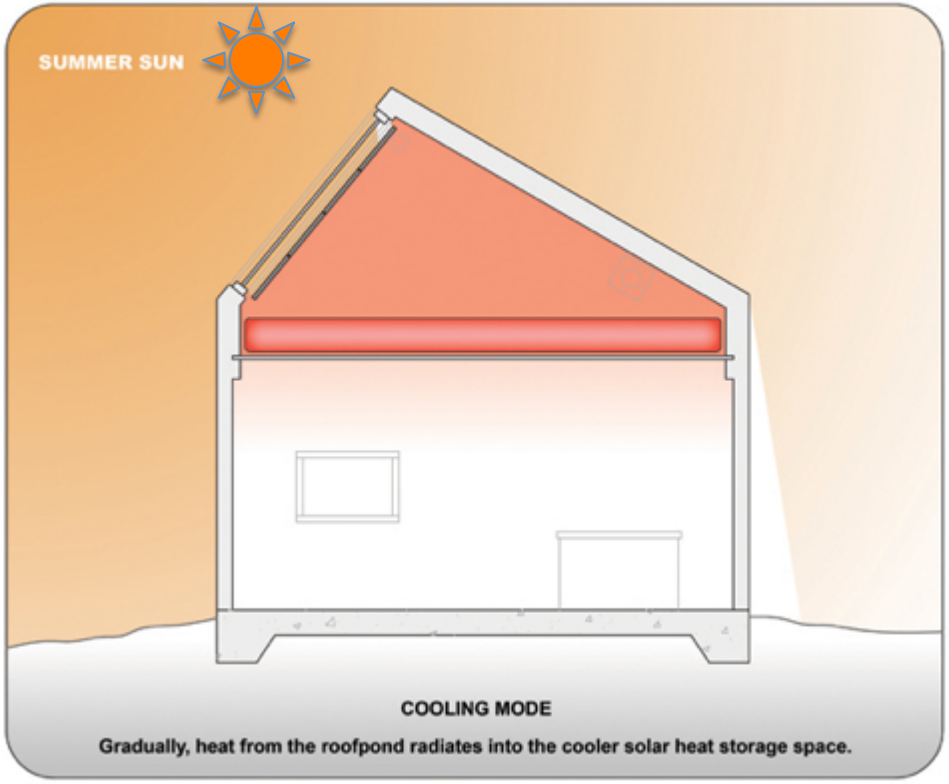

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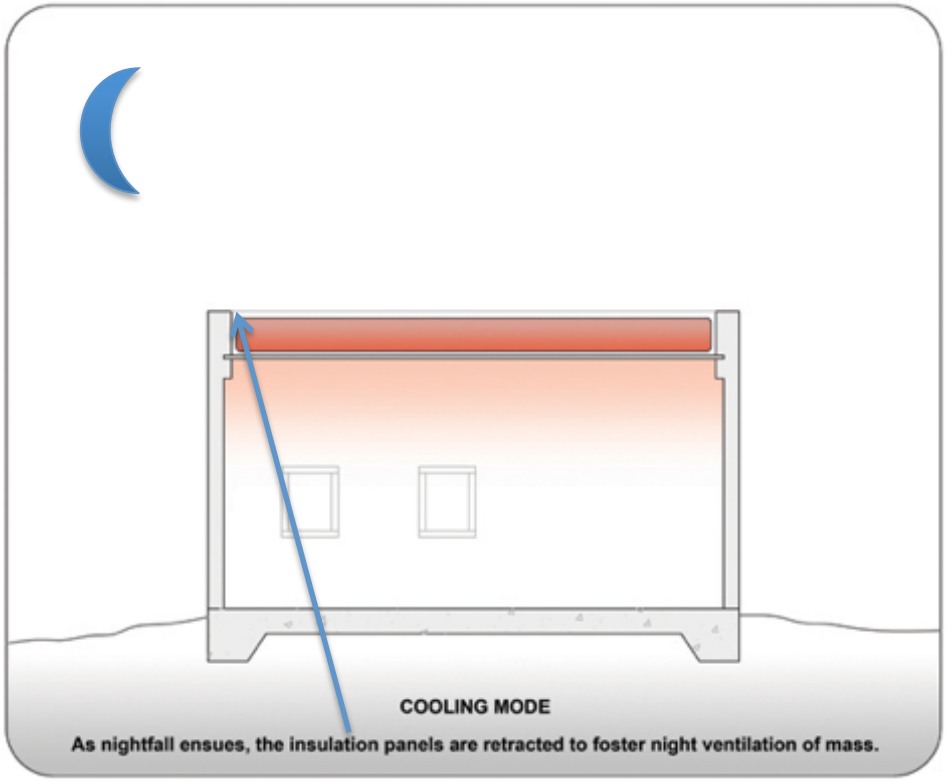

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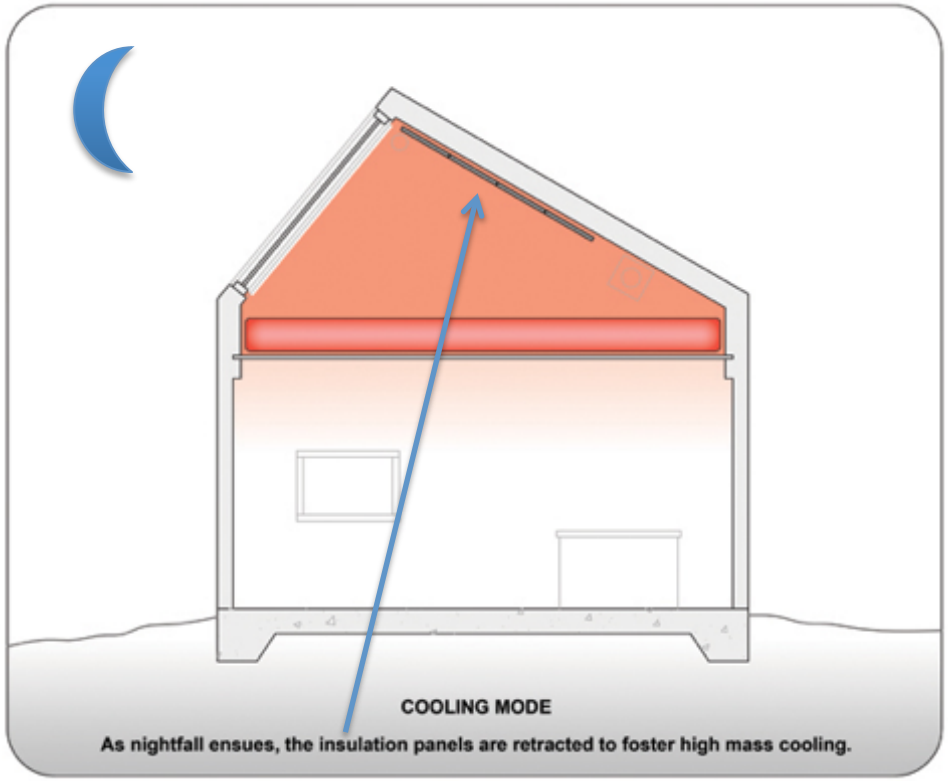

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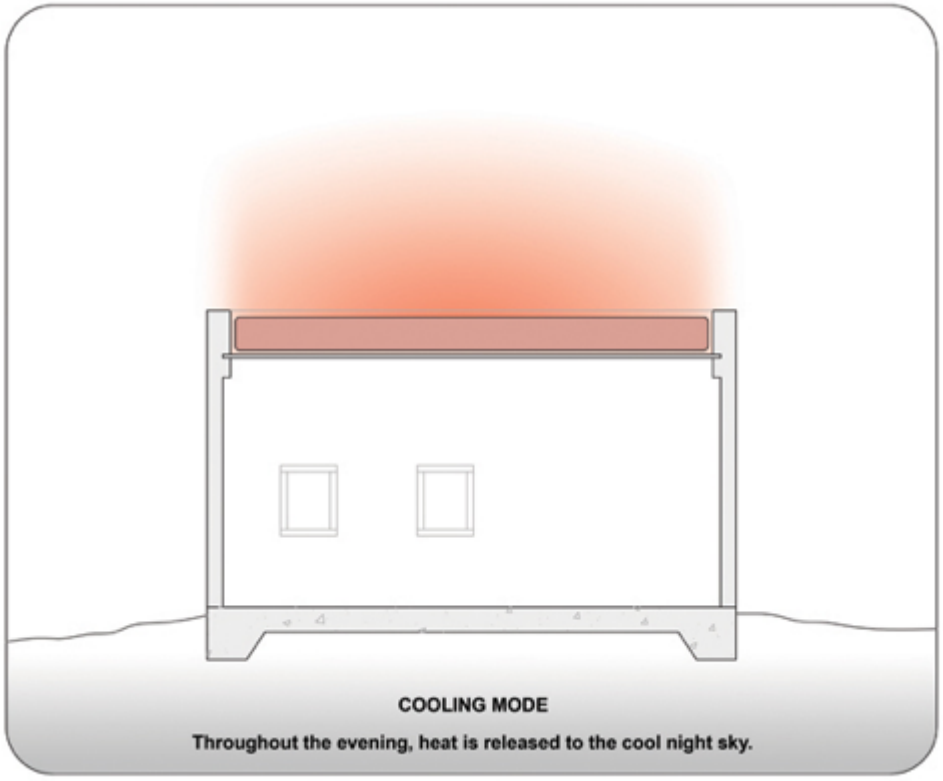

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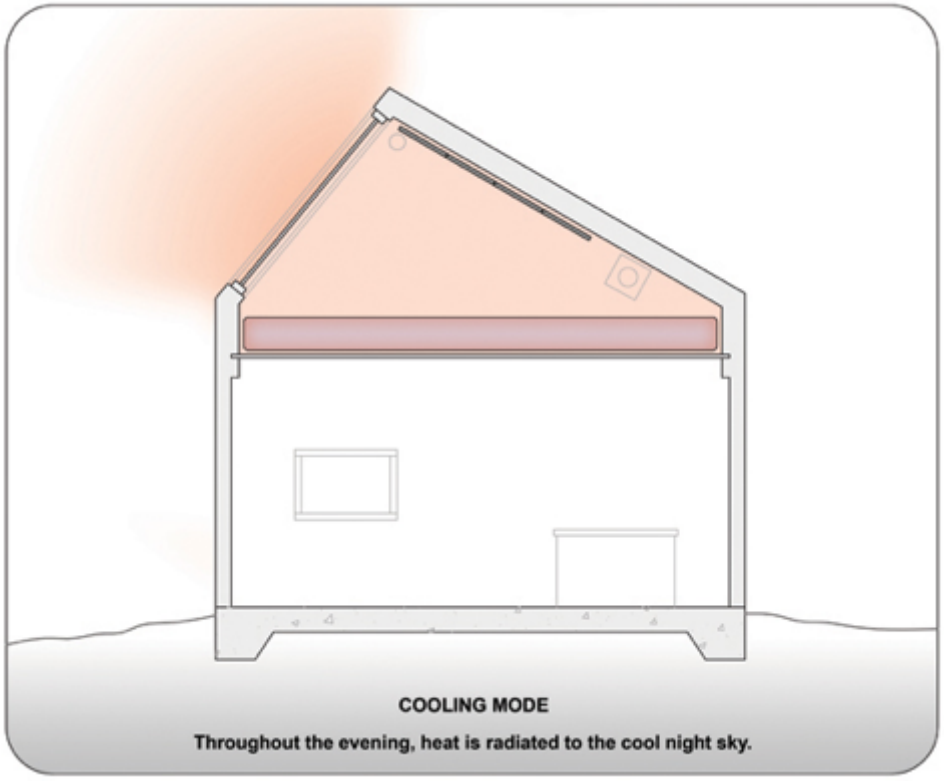
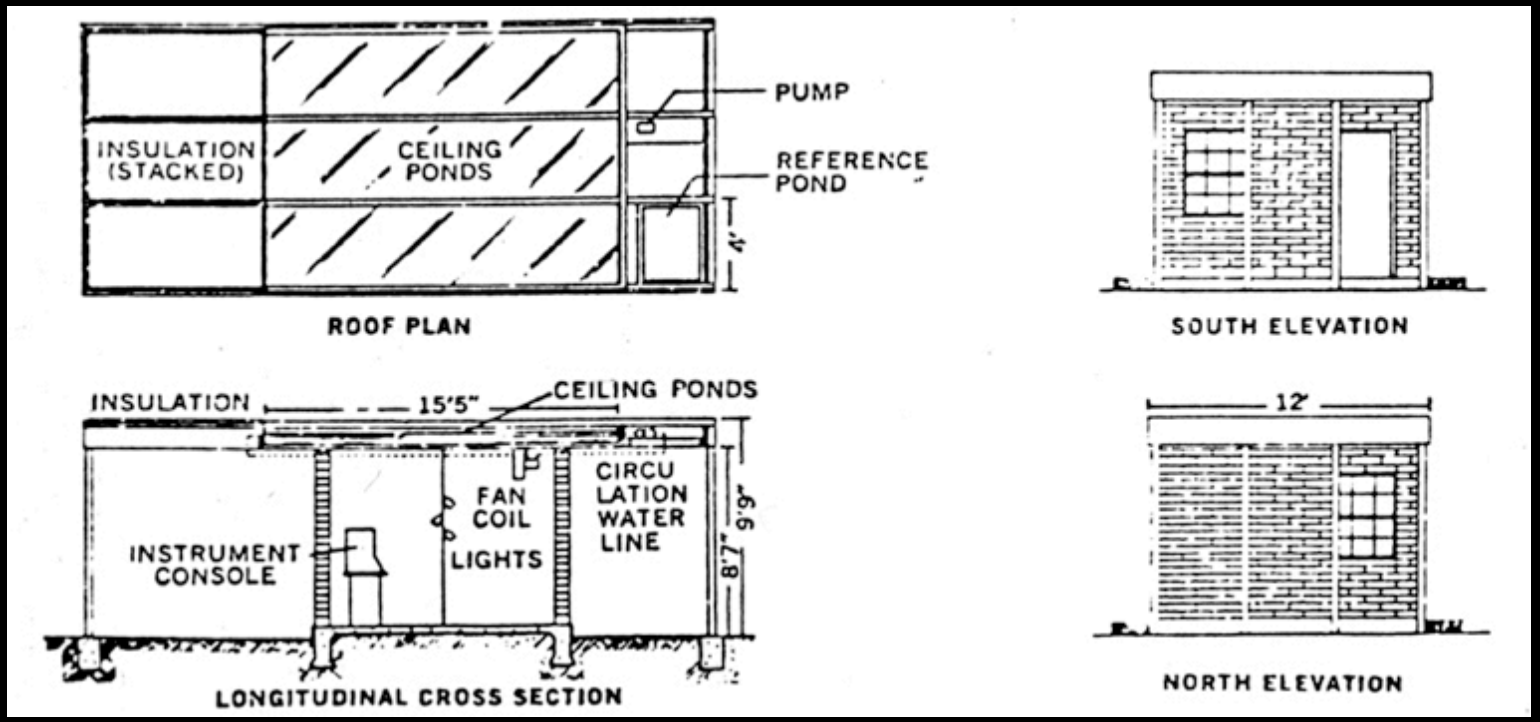
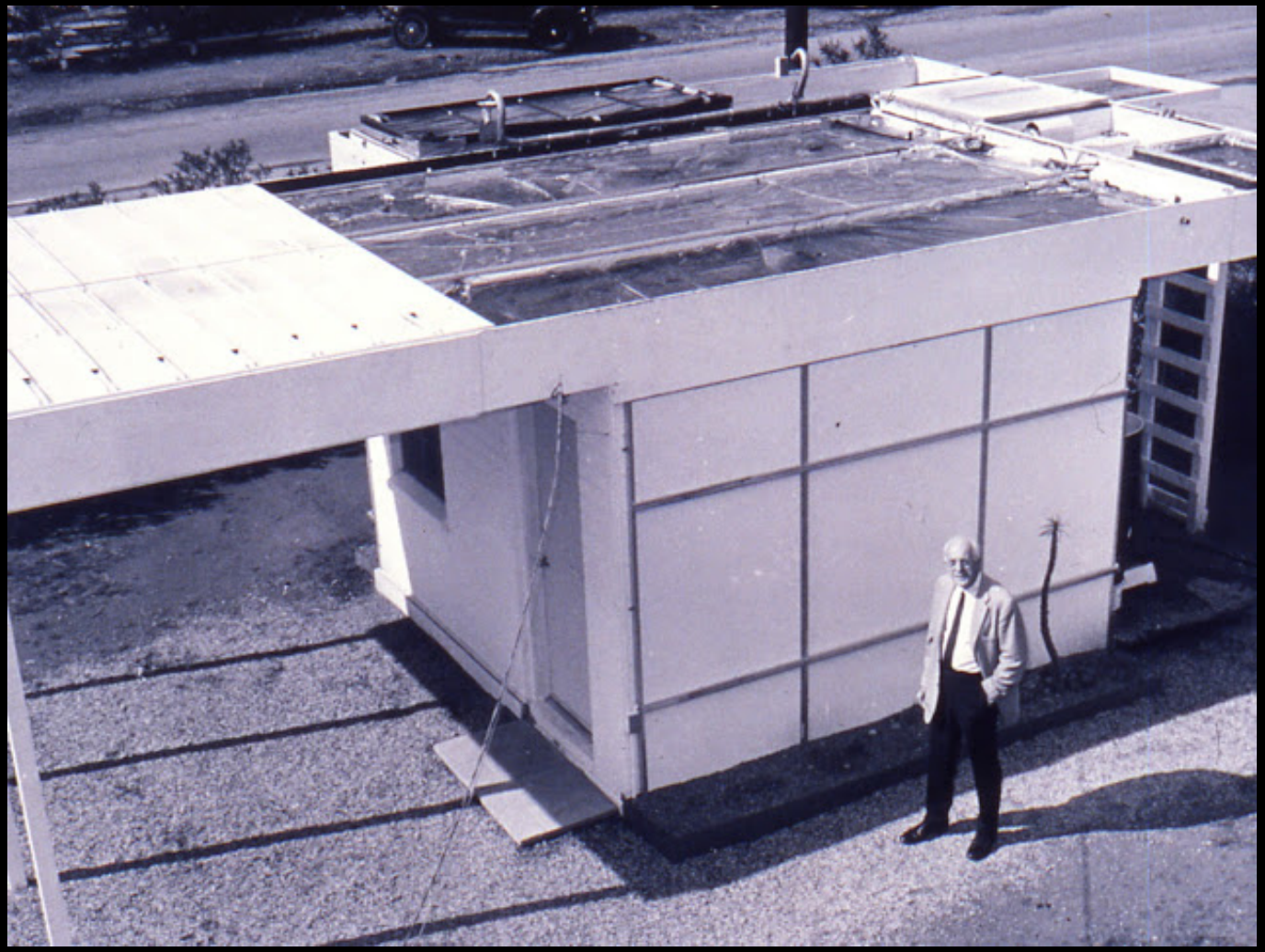


1967 Phoenix Prototype Test Structure

10’ x 12’ 120 Sq. Ft.
Aggregate Lightweight Concrete Block Walls/Vermiculite Filled
External 1.5” Rigid Polyurethane Insulation on the East and West Walls
External insulation on north and south foundations and 4” thick concrete floor slab
4’ x 8’ panels 1.5” thick polyurethane movable insulation
South side overhang Carport for movable rooftop
12’x12’ Window on North and South Walls
Entry door on South Wall
6”-7” thick water filled bags on supported 26 gauge steel sheets

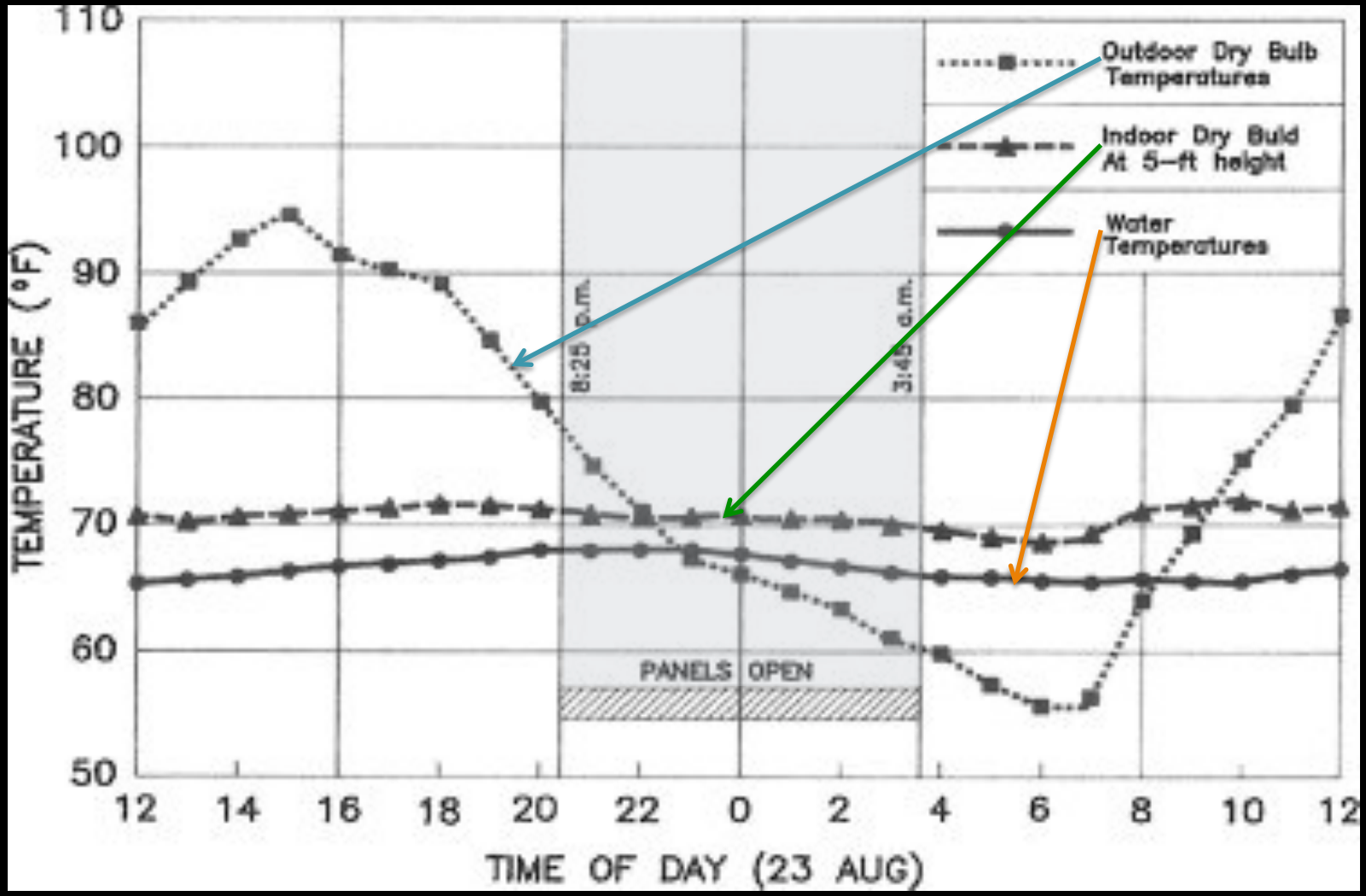


1967 Phoenix Prototype Test Structure



Roofpond inventor, Harold R. Hay, 1967.
Image courtesy of the Natural Energies Advanced Technology Laboratory at the University of Nevada, Las Vegas

One day processed data measured:
Phoenix prototype test building, August 23



Yearly processed data measured from the Phoenix prototype test building.

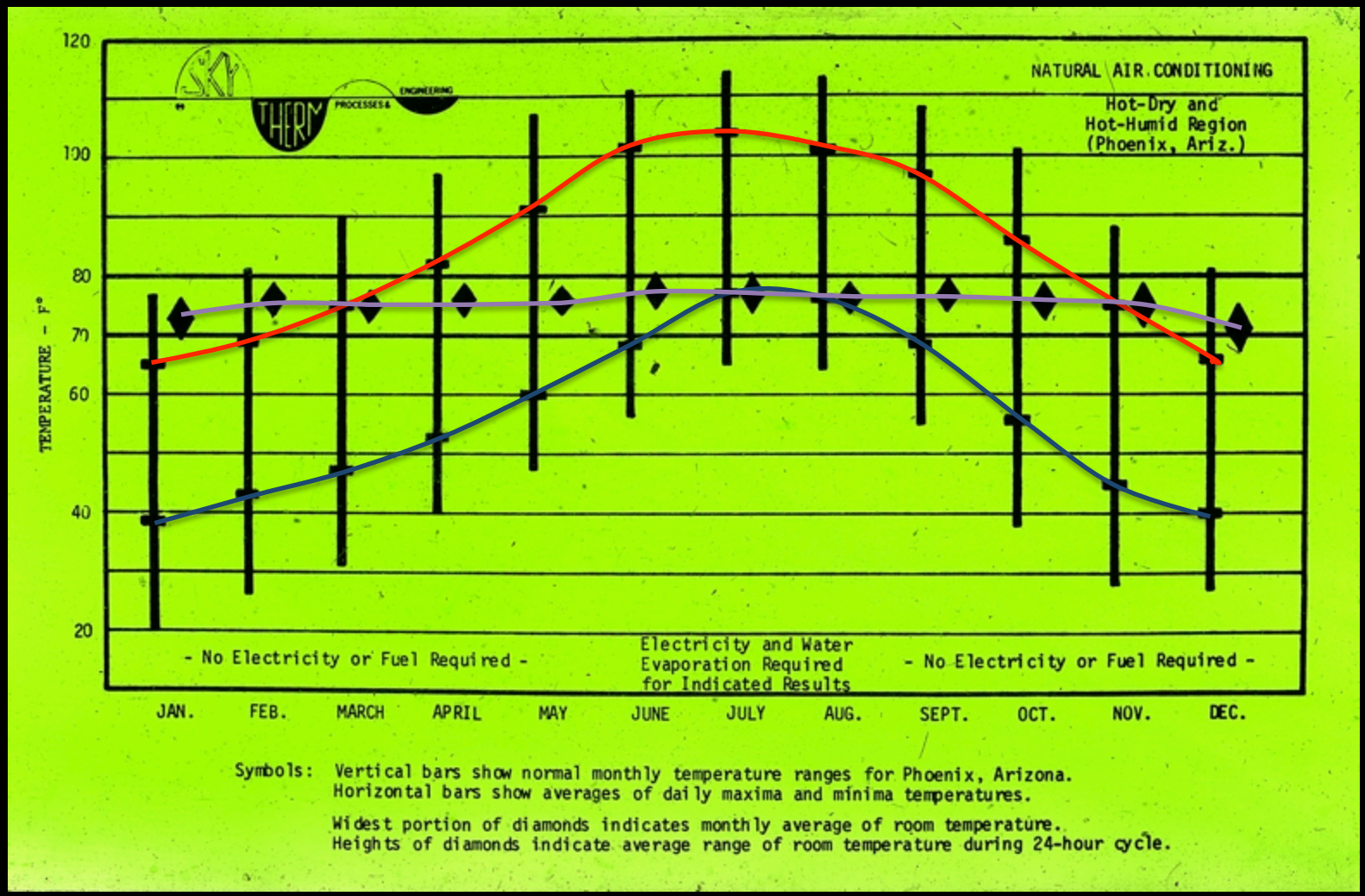
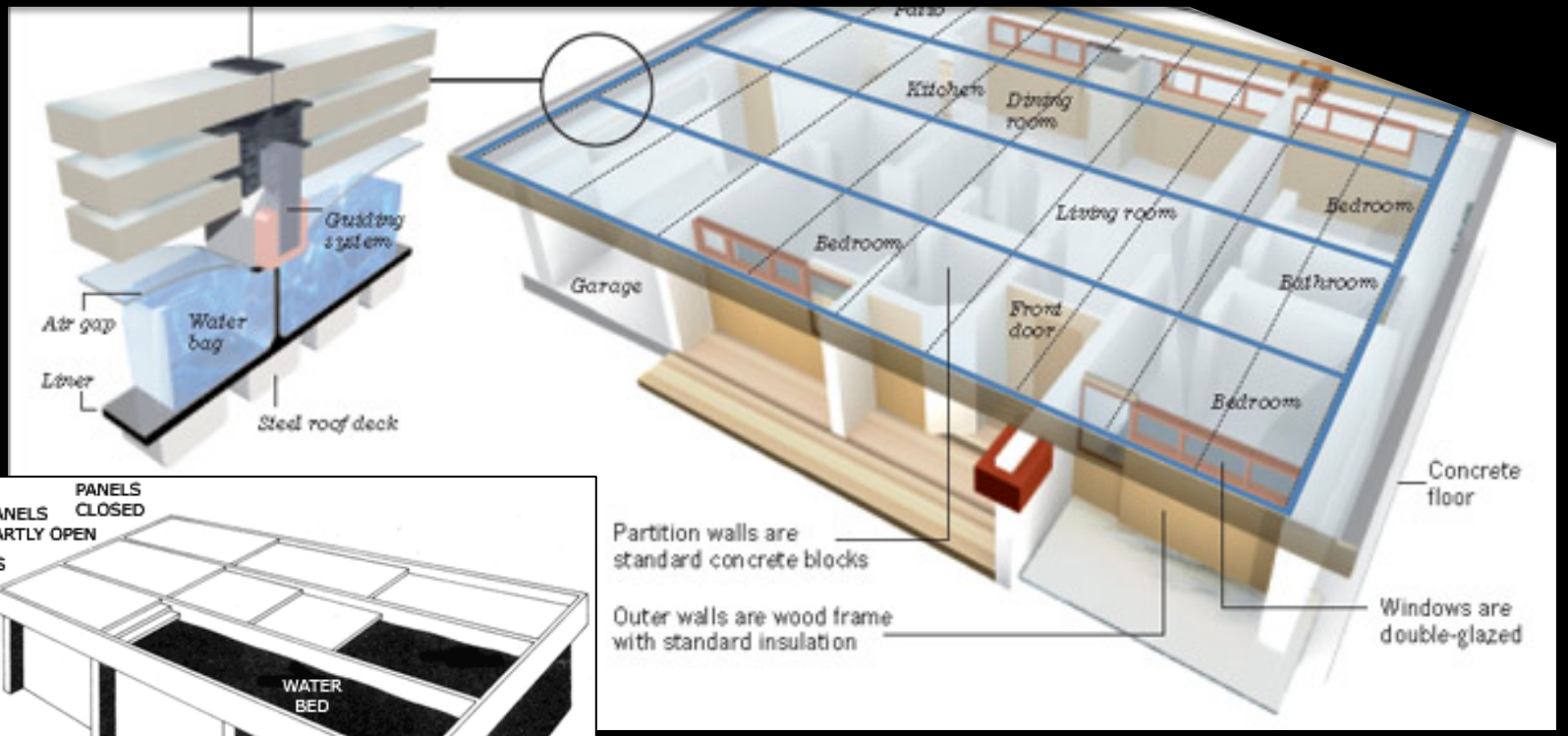


Image courtesy of the Natural Energies Advanced Technology Laboratory at the University of Nevada, Las Vegas

SkyTherm

In 1973 they built a 1100 sq. ft. second house in Atascadero, CA



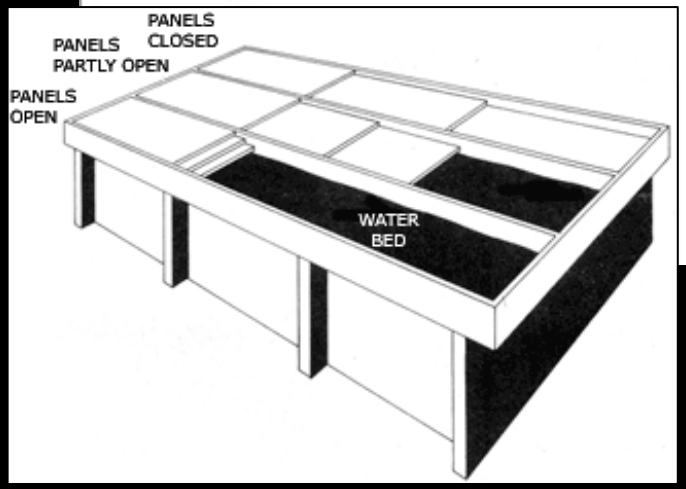


Image courtesy of the Natural Energies Advanced Technology Laboratory at the University of Nevada, Las Vegas

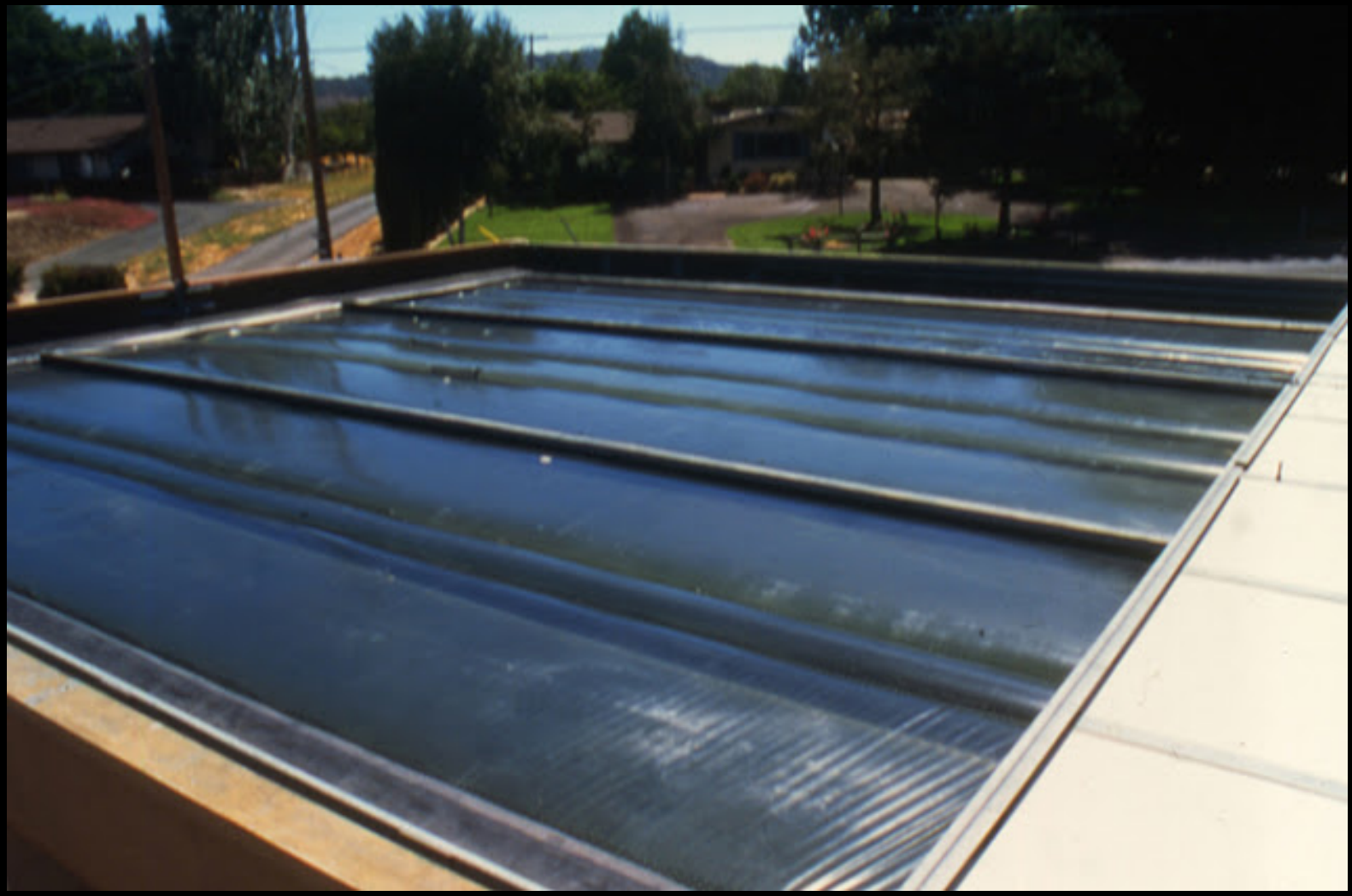


Image courtesy of the Natural Energies Advanced Technology Laboratory at the University of Nevada, Las Vegas

It's been heating and cooling without electricity for the past 40 years now.

Its only recognition was the *1976* Bicentennial awards for the categories of environmental and solar energy.

The Energy Technology Engineering Center report contracted by the US DOE conclusion:

"A well-designed roofpond can maintain comfortable indoor ambient air temperatures in climates with an outdoor temperature range between 32°F and 115°F (Marlatt 1984)"

What about northern climates that get below 32°F ?

CONTINUED RESEACH

Alfredo Fernandez-Gonzalez, Director
School of Architecture,
University of Nevada, Las Vegas.

"Analysis of the thermal performance and comfort conditions produced by five different passive solar heating strategies in the United States midwest."

Solar Energy, May 2007

Climate normals for Muncie, Indiana

City												Muncie	
State												IN	
Lat												40.13N	
Long												85.25W	
Elevation												286.5 m above seal level	
	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Minimum temperature (°C)	−8.8	−7.0	−1.6	4.1	10.7	15.7	17.8	16.6	12.1	5.5	0.3	−5.6	5.0
Maximum temperature (°C)	0.5	3.1	9.1	15.9	22.1	27.2	29.4	28.2	24.6	17.9	10.0	3.4	15.9
Mean temperature (°C)	−4.2	−1.9	3.8	10.0	16.4	21.4	23.6	22.4	18.3	11.7	5.2	−1.1	10.4
Precipitation (cm)	5.2	5.7	7.9	9.1	10.6	10.9	10.1	8.9	7.6	6.7	8.6	7.7	98.9
HDD base 18.3 °C	698	568	452	252	102	12	1	7	47	210	395	602	3346
CDD base 18.3 °C	0	0	0	2	41	106	164	132	47	6	0	0	498

Outdoor Design Conditions Comparison: Basis 66.2F°

Minneapolis, Minnesota

HHD 7981

CCD 824

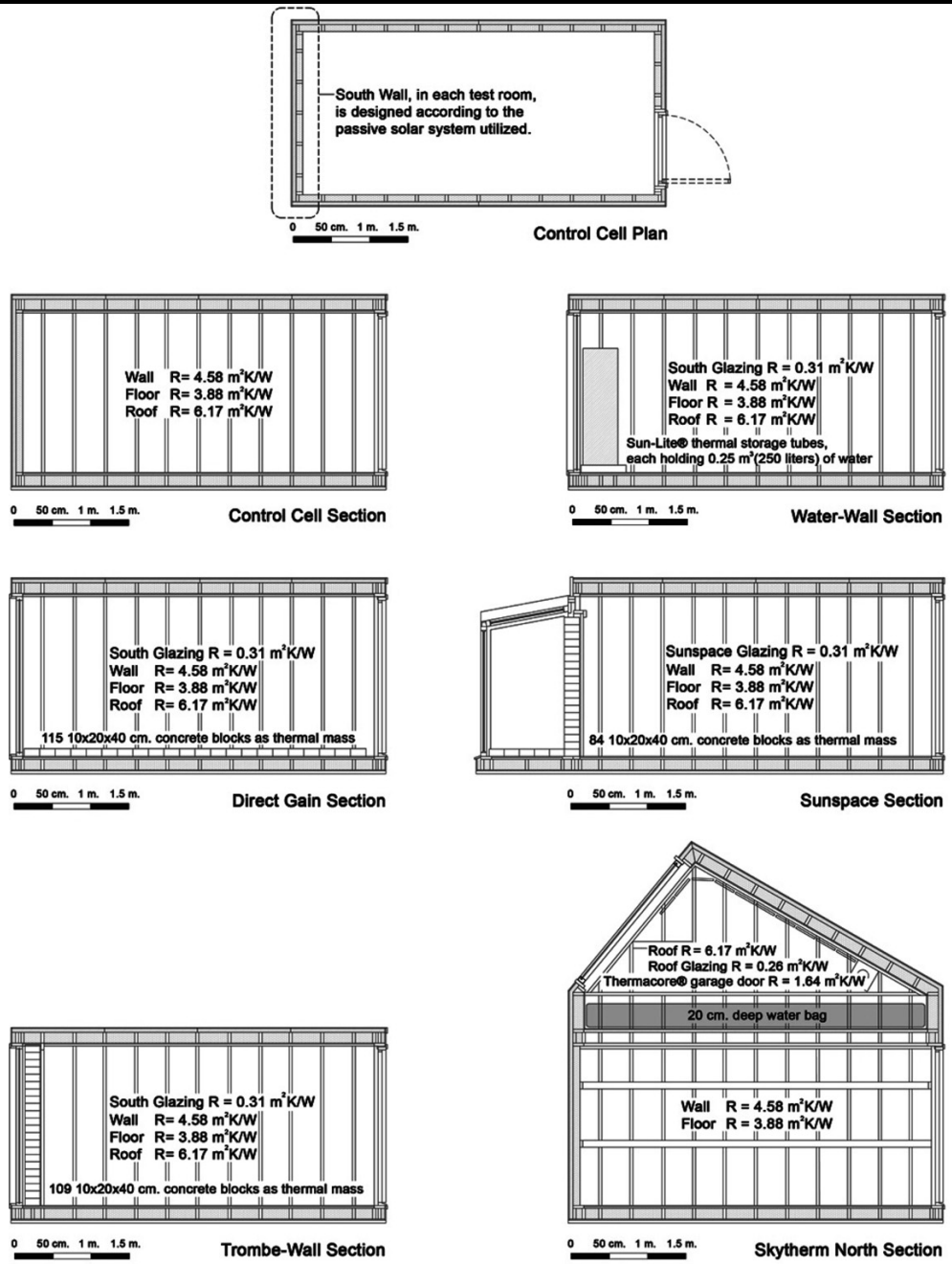


Fig. 2. Basic floor plan and longitudinal sections of each one of the test cells.

Passive solar features specific to each strategy

	CC	DG	TW	WW	SS	RP	
Floor area (m^2)	11.91	11.91	11.91	11.91	11.91	11.91	
UA total (W/°C)	28.74	35.47	34.93	34.75	45.54	Day 44.09	Night 29.93
Measured ACH	0.68	0.85	0.81	0.86	0.67	0.91	
Solar collector area (m^2)	–	4.28	4.28	4.28	6.05	4.47	
Thermal storage capacity (kJ/°C)	569.57	1786.17	1728.84	4909.57	1517.80	9629.80	

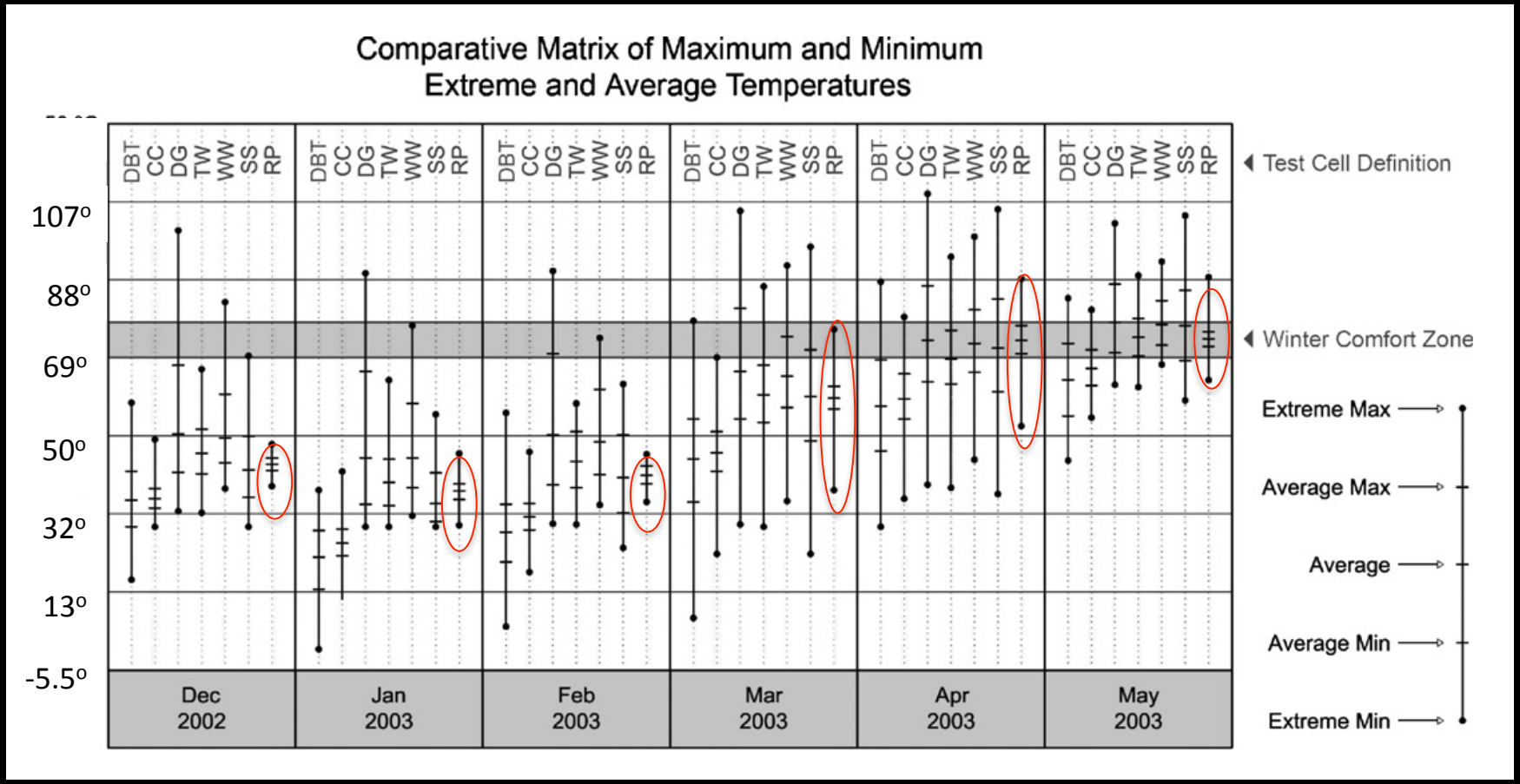
Table 3
performance indicators of each strategy

	CC	DG	TW	WW	SS	RP
Average diurnal swing (°C)	2.26	7.80	3.32	4.99	5.28	1.24
Maximum diurnal swing (°C)	2.41	10.27	3.79	5.94	5.74	1.44
Average simultaneous north–south variation (°C)	0.07	2.89	0.45	0.98	0.32	0.11
Maximum simultaneous north–south variation (°C)	0.15	3.68	0.52	1.22	0.50	0.20

Roofpond (RP) Interior | Sunspace (SS) Interior | Water-Wall (WW) Interior

Trombe-Wall (TW) Interior | Direct Gain (DG) Interior | Control Cell (CC) Interior

Control test-cells show low diurnal swings in the roof pond test cell. This should be a pre-requisite to achieving thermal comfort.



CC/Control Cell, DG/ Direct Gain, TW/Trombe Wall, WW/ Water Wall, SS/Sun Space, RP/Roof Pond

RoofPond North
with movable insulation

Achieving optimal thermal comfort from a passive solar strategy using the most effective method in a northern climate.

RoofPond North with movable insulation
Inver Grove Heights, MN
1979

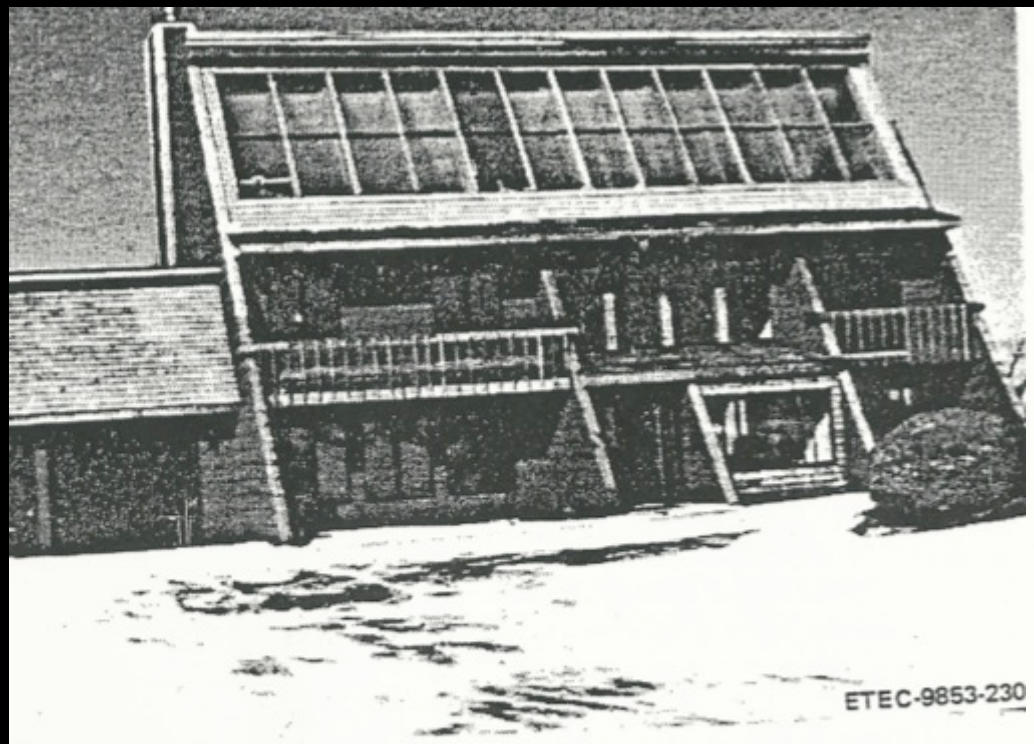


Figure 2-17. Skytherm North Near Minneapolis, Minnesota (Taken from Ref. 69)

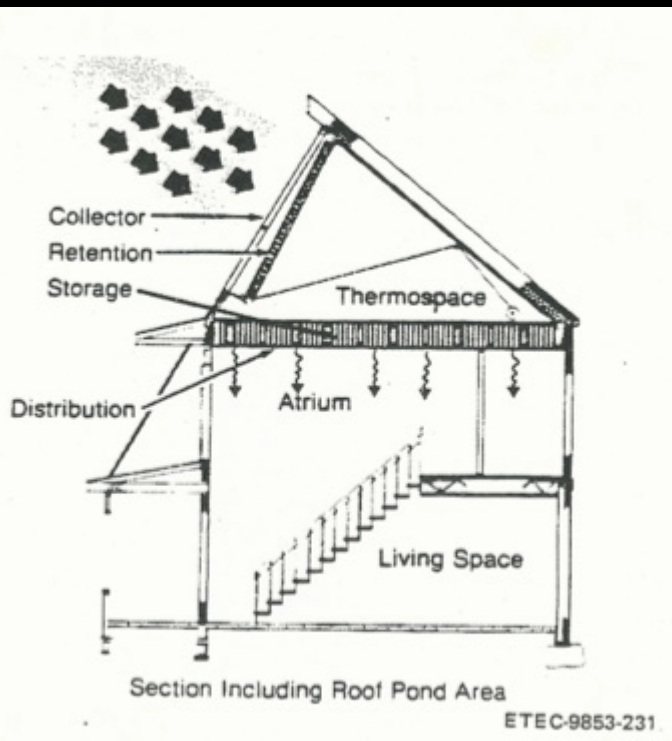
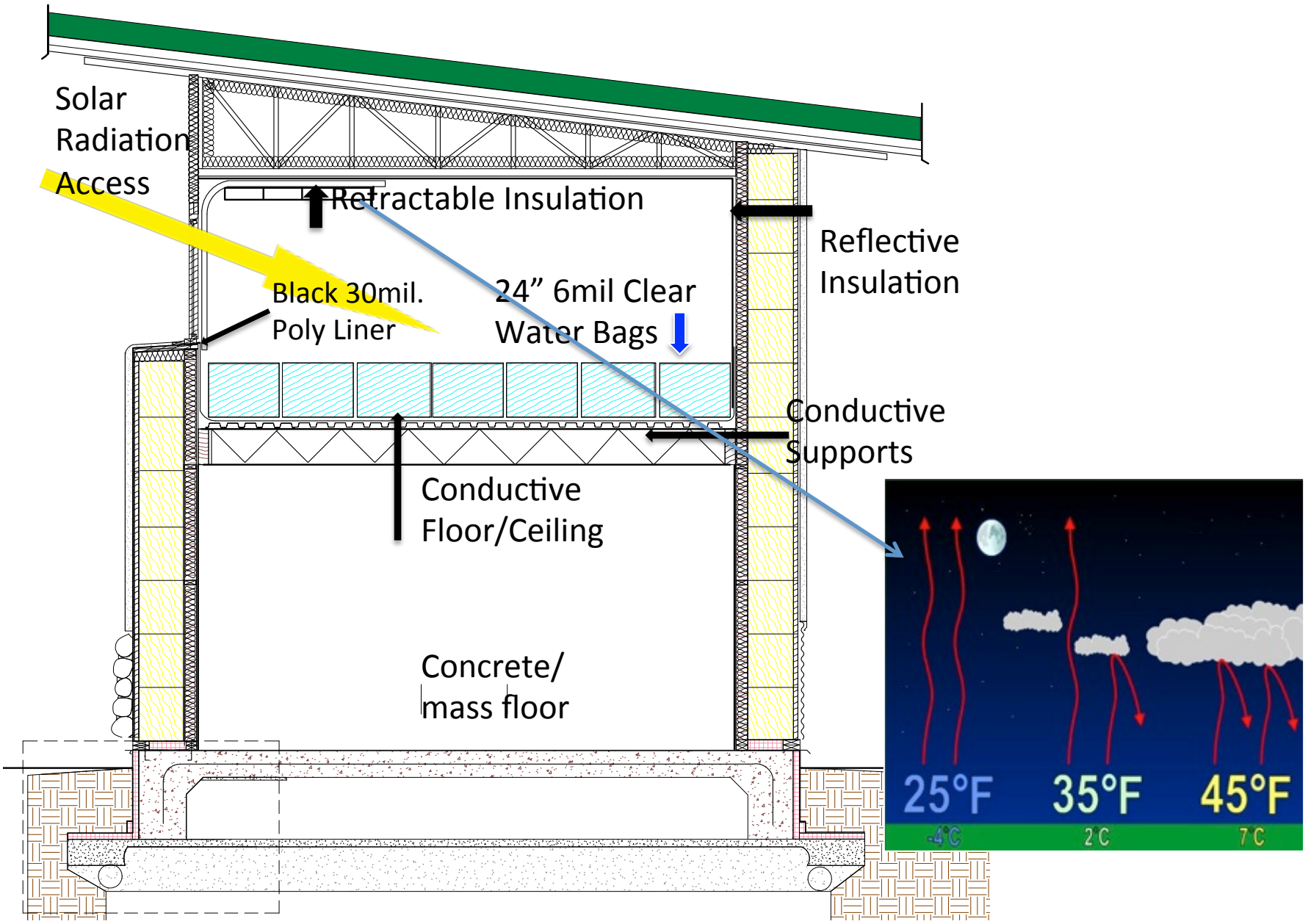


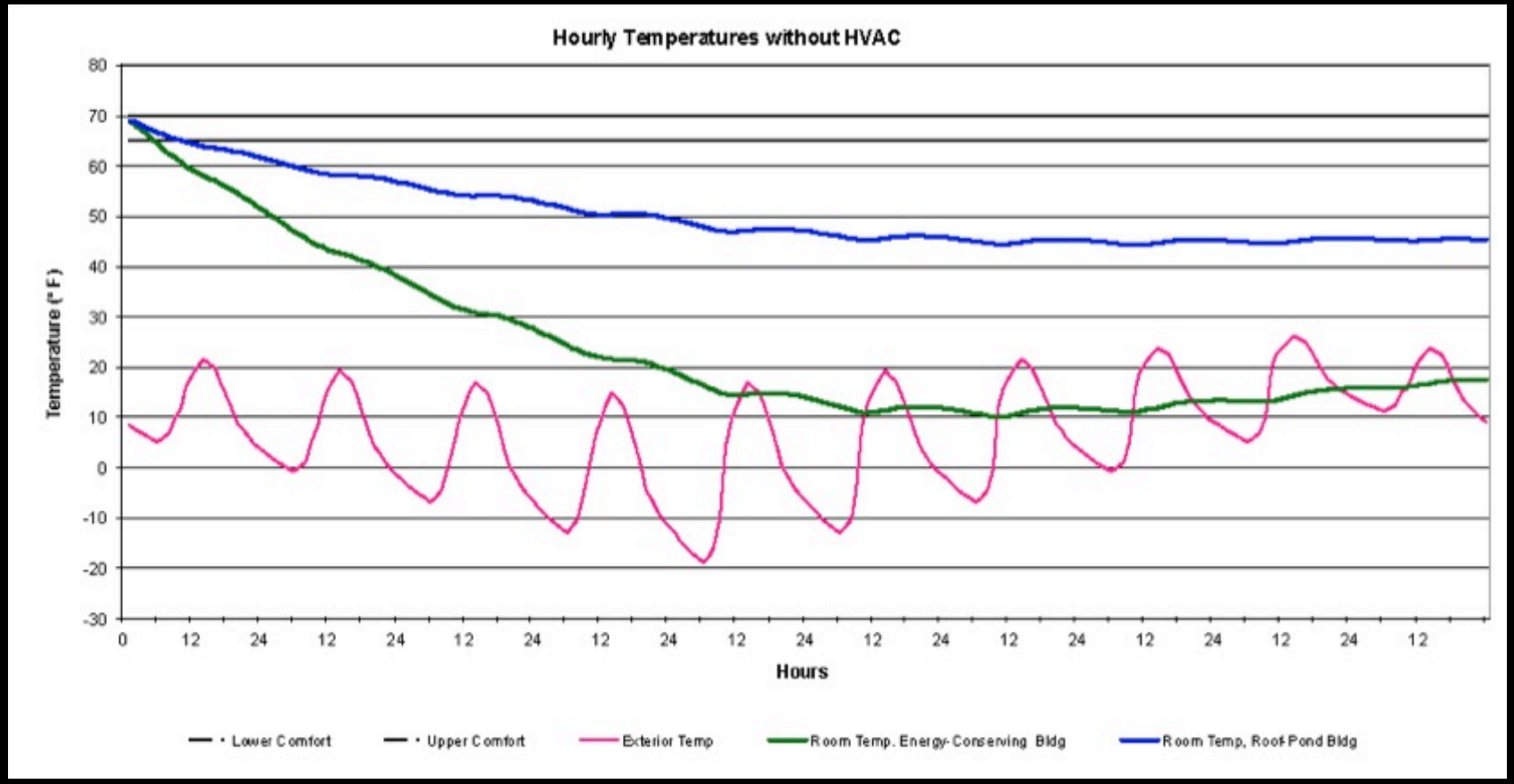
Figure 2-18. Passive Heating System Schematic of Skytherm North (Taken from Ref. 69)


Solar
Radiation
Access
Retractable Insulation
Reflective
Insulation
Black 30mil.
Poly Liner
24” 6mil Clear
Water Bags
Conductive
Supports
Conductive
Floor/Ceiling
Concrete/
mass floor
25°F
35°F
45°F
-4°C
2°C
7°C

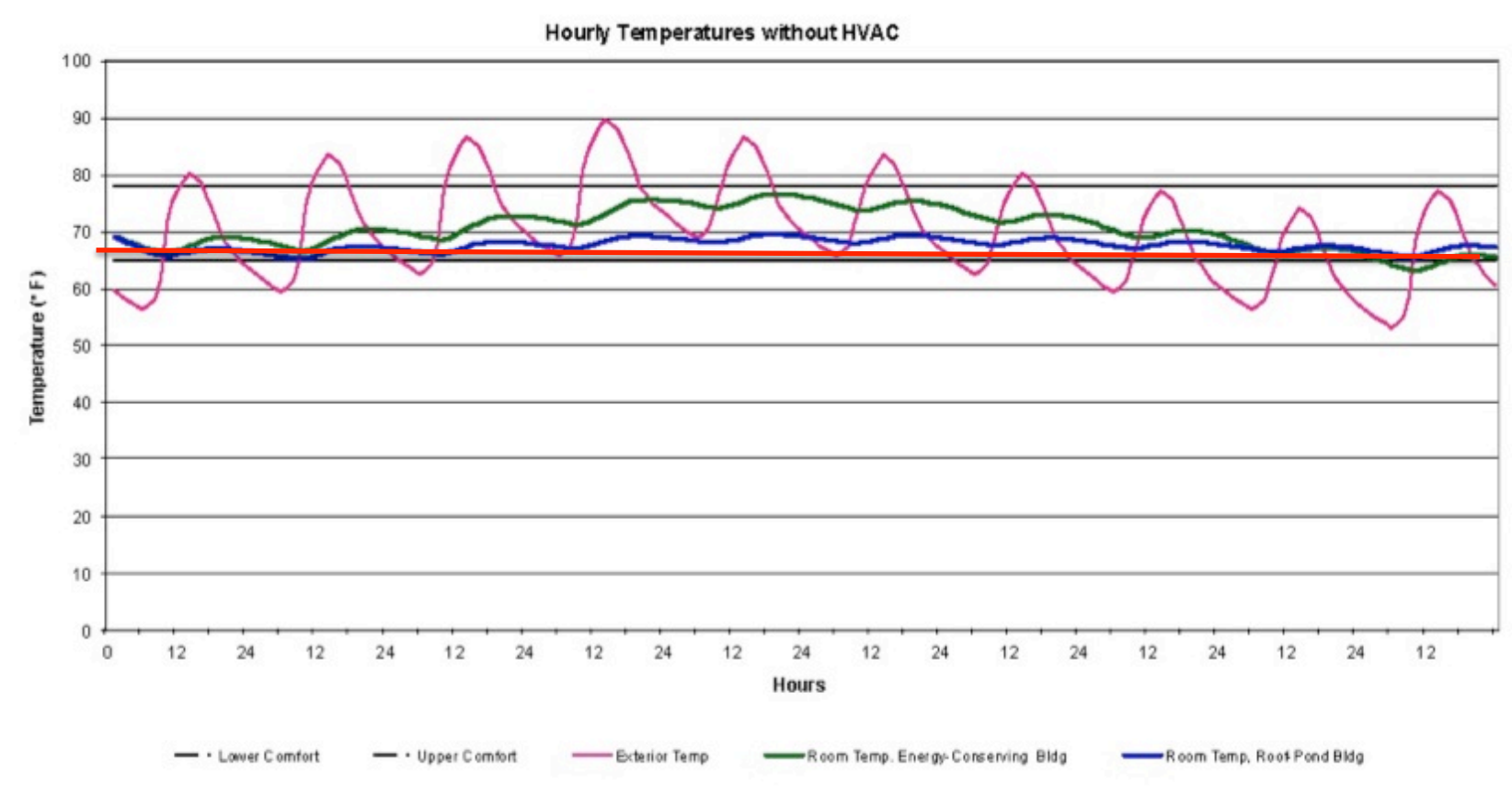
Case study: Roof Pond North, 2014

Brainerd, Minnesota	46˚21’29”N 94˚12’03”W
HDD65˚F	8600
CDD65˚F	512
Winter Dry Bulb ˚F	-20˚F
Summer Dry Bulb	86˚F
Summer Wet Bulb	71˚F
Mean Daily Range (˚F)	19˚F

RP_performance software
December comparison



RP_performance software
August comparison



HEED: Home Energy Efficient Design
Free Software

http://www.energy-design-tools.aud.ucla.edu/heed/

Slab + 24” of water without PV

HERS	3
No heating needed	8326 HDD
Heating needed	434 HHD
KwH Used for heat	609 yr/$66

Skytherm™

Harold Hay may have been the obstacle for this technology not moving forward, and, from what I understand, the reason there are few houses with this system, even though it is simple and practical

Because of its tested success, multiple roofpond structures are still being tested in diverse locations around the US and the world, partially due to resistance to the concept.

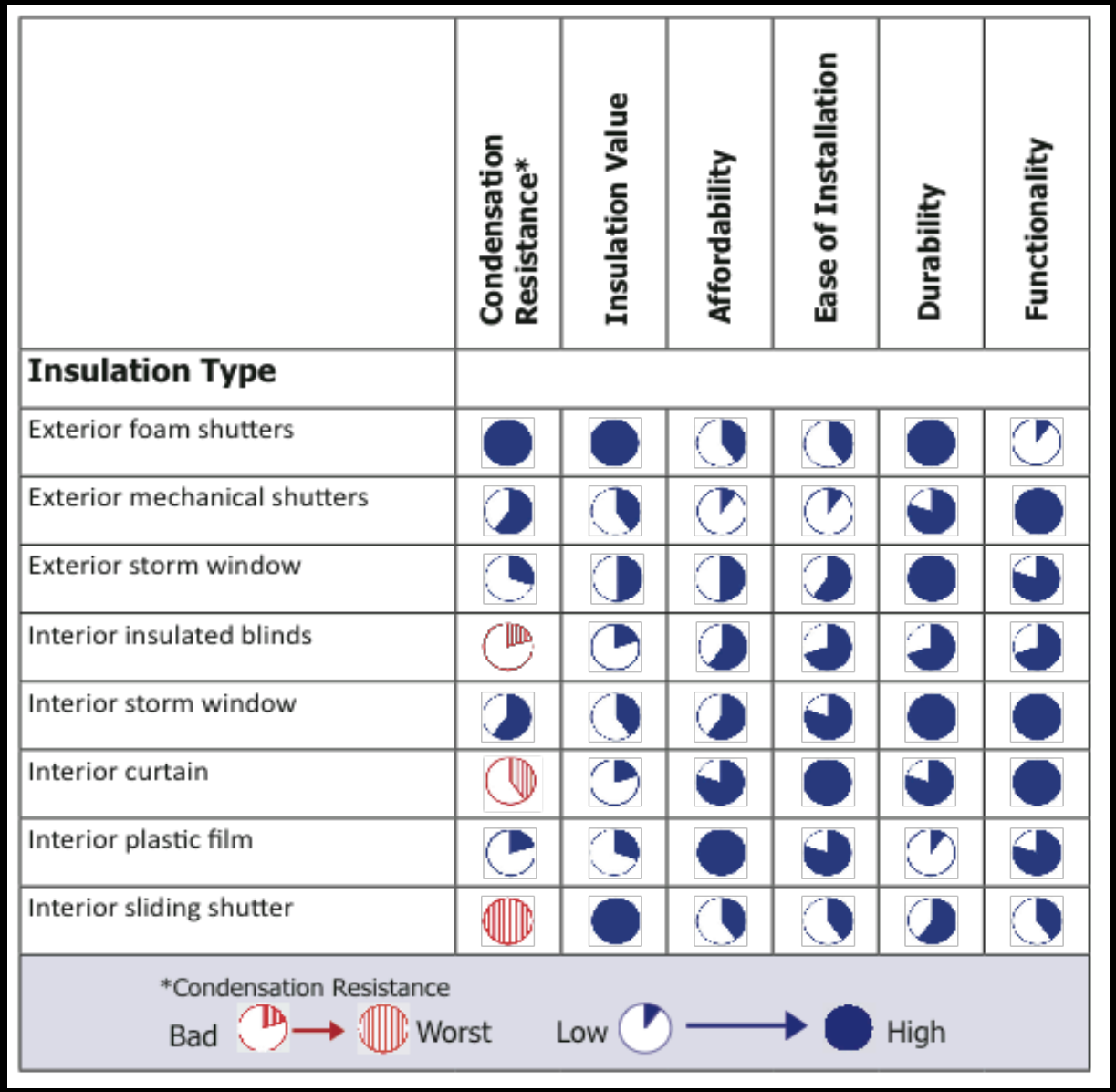
Historically, roofpond applications have proved to be viable low-cost solutions for both heating and cooling in a wide variety of climate regions.

A Word about Movable Insulation

1. https://www.youtube.com/watch?v=MroKo-598T0

2. https://www.youtube.com/watch?v=Xen_VWyDezY

Cold Climate Housing Research Center, Fairbanks Alaska



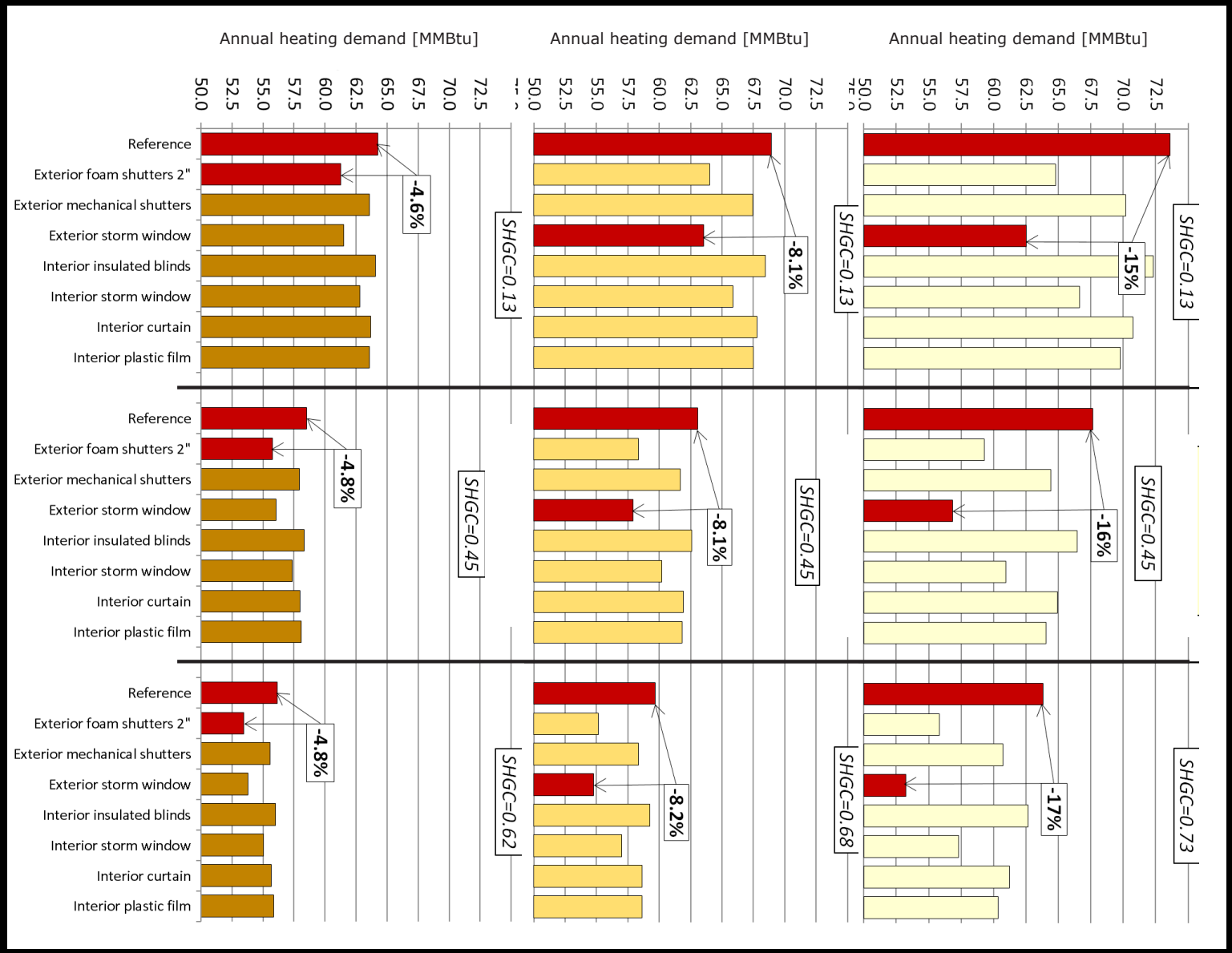
Insulation Type	Condensation Resistance*	Insulation Value	Affordability	Ease of Installation	Durability	Functionality
Exterior foam shutters						
Exterior mechanical shutters						
Exterior storm window						
Interior insulated blinds						
Interior storm window						
Interior curtain						
Interior plastic film						
Interior sliding shutter						

*Condensation Resistance

Bad → Worst

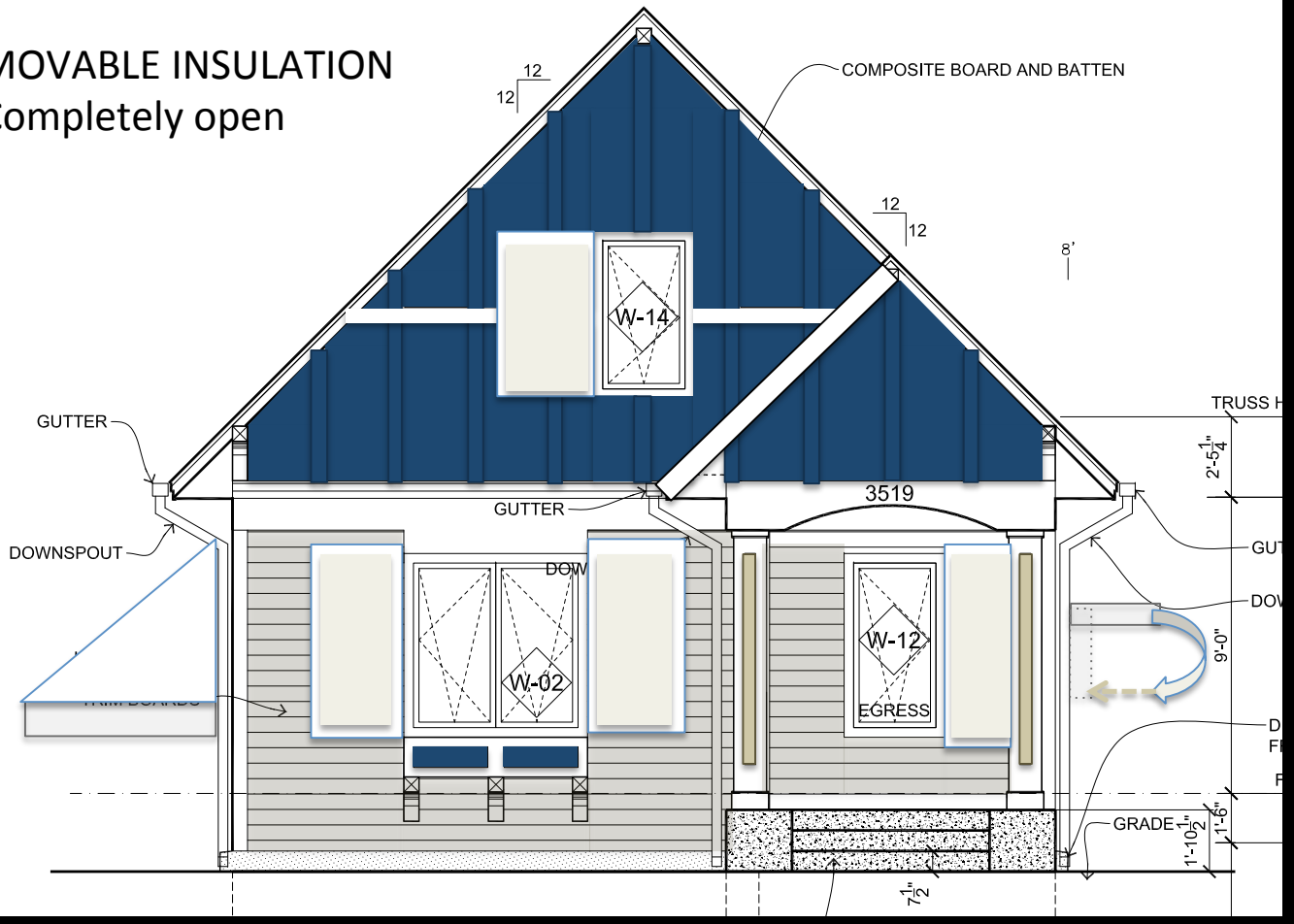
Low → High

Another Word about Movable Insulation

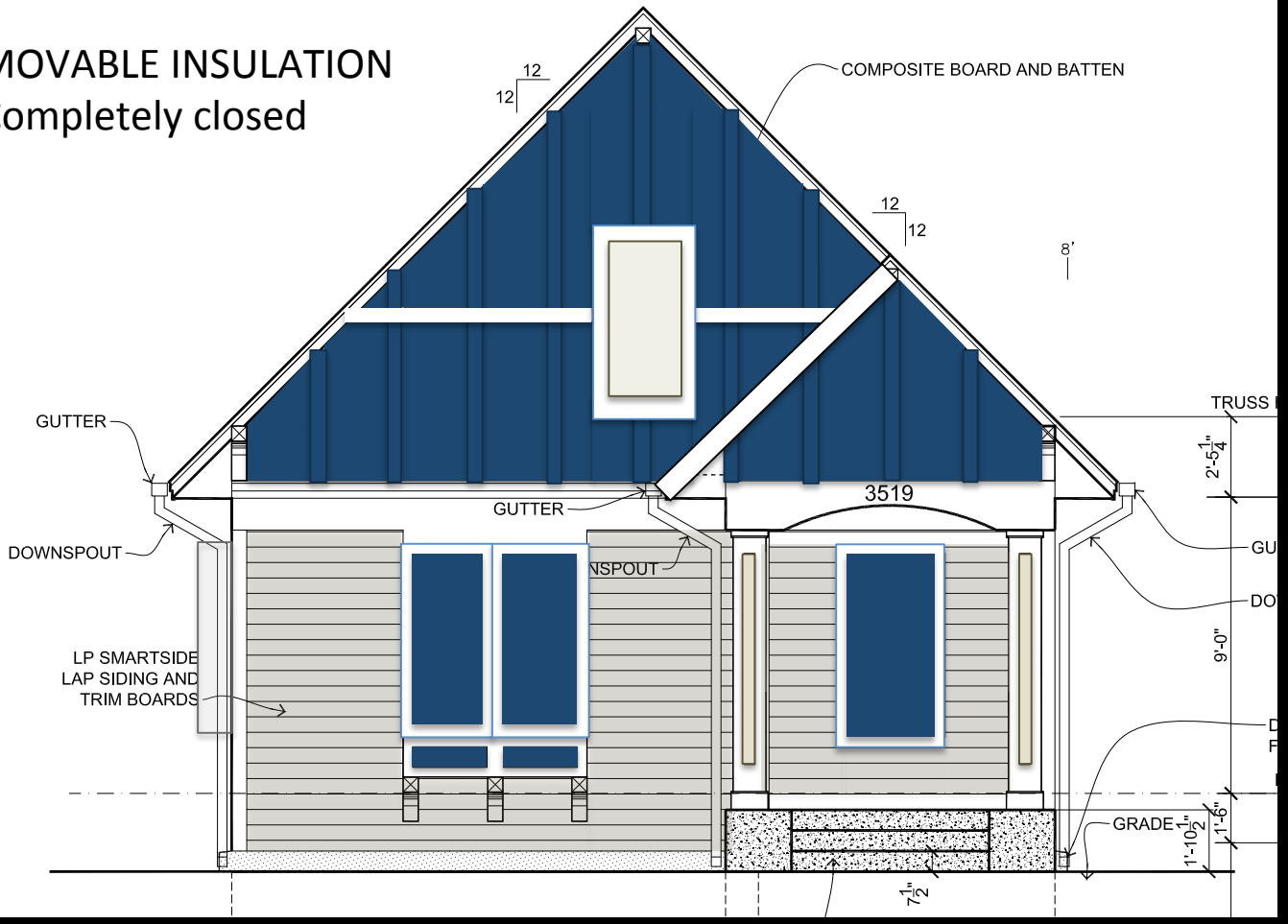


WINDOW U VALUES U = 0.20 U = 0.28 U = 0.48

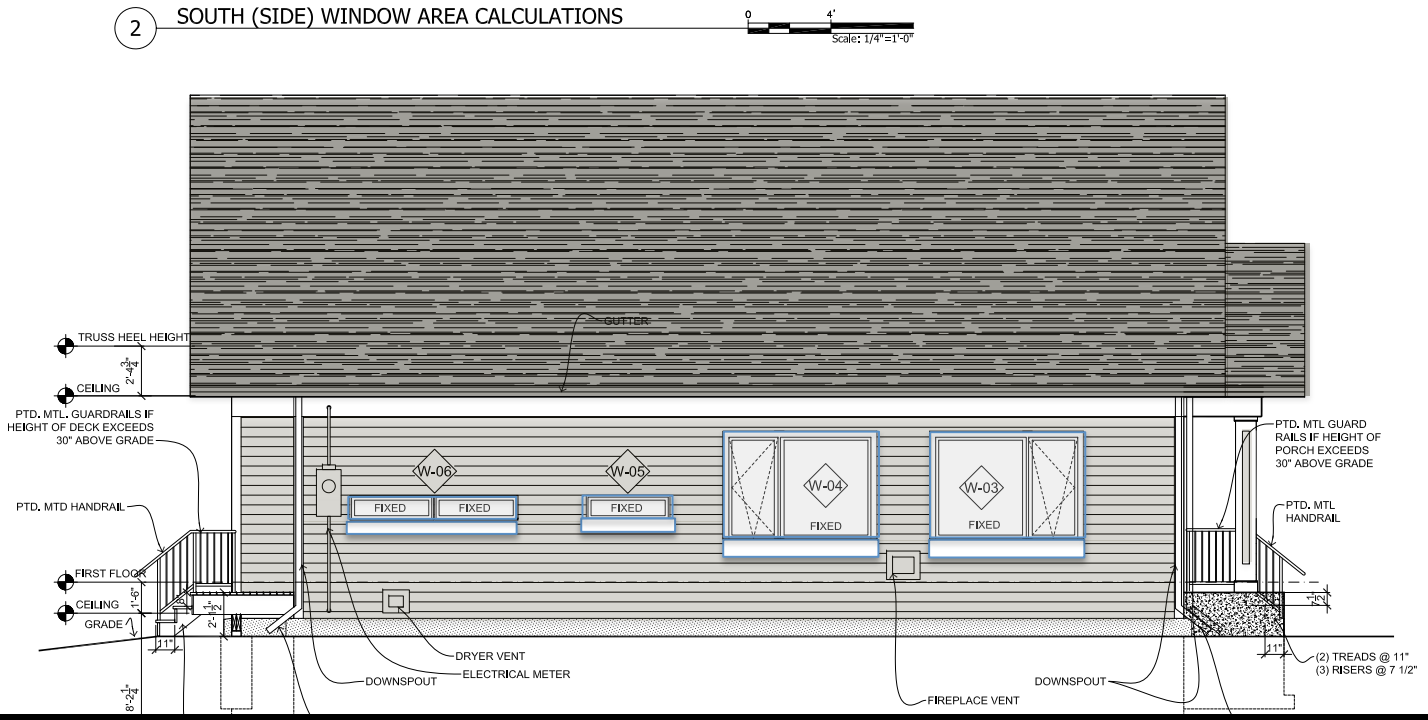
MOVABLE INSULATION
Completely open



MOVABLE INSULATION
Completely closed



MOVABLE INSULATION: Completely open
Winter application South side closed during the night, anytime when occupant is gone, and if there is not any solar radiation (sunlight) to be gained during the day if so desired.



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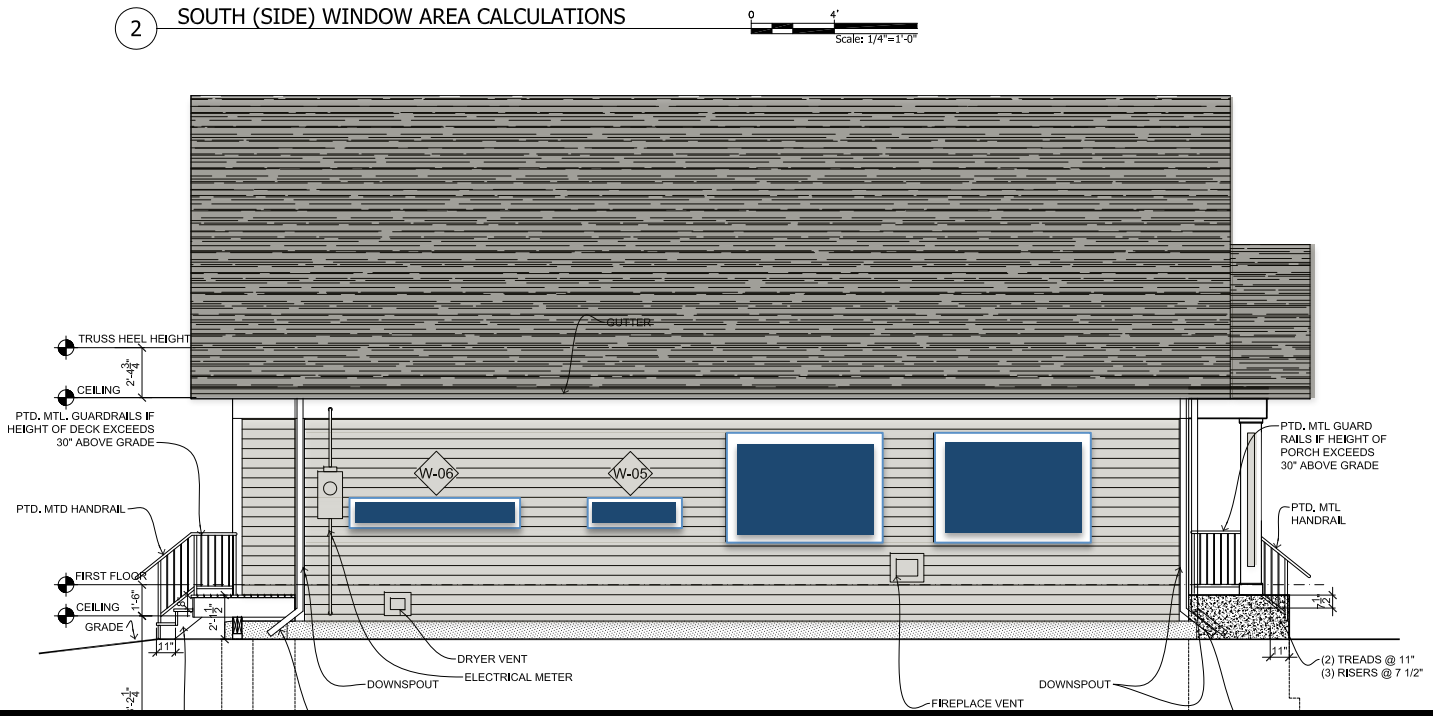

More Words about Movable Insulation

Roofponds and Exterior moveable insulation need to be looked to as effective passive solar strategies, which will strongly contribute to energy demand reduction in the building sector from now and into the future.

As more people learn and experience the concept, sooner or later, these systems can grow into a viable and highly desirable option for reducing heating and cooling loads.

We need to invest and move forward real living situations in which to show not only the value, but also the importance.

COMFORT AND THERMAL PERFORMANCE OF PASSIVE SOLAR TEST ROOMS IN MUNCIE, INDIANA.

Alfredo Fernández-González
School of Architecture, University of Nevada, Las Vegas Las Vegas, NV 89154-4018

http://web.unlv.edu/labs/neatl/documents/2004_ASES_AFG_1.pdf

RP_PERFORMANCE: A DESIGN TOOL TO SIMULATE THE THERMAL PERFORMANCE OF SKYTHERM NORTH ROOFPOND SYSTEMS

Alfredo Fernández-González
School of Architecture, University of Nevada, Las Vegas Las Vegas, NV 89154-4018

http://web.unlv.edu/labs/neatl/documents/2004_ASES_AFG_2.pdf